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ROYAL SOCIETY

SIR WILLIAM HUGGINS

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THE ROYAL SOCIETY

FROM AN ENGRAVING BY W. HOLLAR

THE ROYAL SOCIETY

OR, SCIENCE IN THE STATE AND IN THE SCHOOLS

BY

SIR WILLIAM HUGGINS, K.C.B., O.M.

D.C.L., LL.D., Sc.D., F.R.S., ETC.

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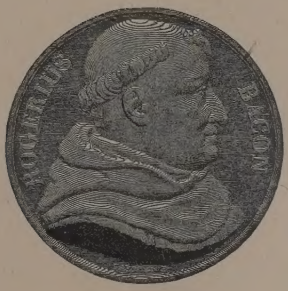

WITH TWENTY-FIVE ILLUSTRATIONS

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1906

TO THE

FELLOWS OF THE ROYAL SOCIETY

A TRIBUTE

OF

GRATEFUL ACKNOWLEDGMENT

PREFACE

I YIELD to the suggestion that has been made to me to print in book form selections from four of my Presidential Addresses which treat of subjects of general interest,—namely, what science, as represented by the Royal Society, has done and is doing now for the nation; and the place that science should take in education.

I do so in the hope that this tetralogy when separately printed may promote, much more widely than it could do if restricted to the publications of the Royal Society, the objects which I set before me in these Addresses. I desired to make better known the great work, hidden indeed from public view, which at great cost to itself the Royal Society, almost from its foundation to the present time, has carried on with great benefit to the State, and through it to the nation at large, outside and in addition to the reading, discussion, and printing of papers of research, which is its first duty as a Society for "the improving of Natural Knowledge."

My Address at the Anniversary of 1904 was devoted to giving as full a sketch as the time allowed of the

advisory relation in which the Society has stood to the Government, and of some of the more important public works and questions which in the past the Society has initiated, supported, or given advice about in connection with the State; and at the same time to pointing out the large number of responsible public duties which to-day rest permanently upon it, through which the Society makes its influence felt strongly for the good of the nation.

Another object I had in view was to rouse attention to one of the most important of the practical questions of the day, if we are to fulfil our mission as a great nation, the necessity of giving science its proper place in all education. In the Address given in 1902, this subject is considered mainly in respect of the supreme influence of science on the industries of the nation; while in the latter part of the Address of last year the intrinsic intellectual value of the teaching of science as a means of enlarging the powers of the mind takes the first place, together with its relative value in education as compared with humanistic studies.

The first part of the Address of 1905 discusses the profound influence which the discoveries of science, in great part the work of the Fellows of the Royal Society, have had upon the general life and thought of the world, especially during the last fifty years.

The remaining Address, given in 1903, considers the remarkable change in the position of the Royal Society

to scientific research which it has itself brought about through the wonderful increase of natural knowledge, due largely to the work of its Fellows. As the number of workers in science increased, the successive differentiation of phenomena which is at the root of all progress became greater, and the inevitable specialisation of natural knowledge into distinct branches rapidly advanced until these specialised activities could no longer be confined within a single Society. In this way there came about the swarming off, as need arose, of special Societies restricted to the study and promotion of a single branch of science, and not like the Royal Society for the improving in its widest sense of natural knowledge. The present and future relationship of the Royal Society to these daughter Societies, to which she has given birth, is considered as far as the limitations of an Address permitted.

The paragraphs placed within brackets are taken from the reports in the *Times* of my speeches at the Anniversary Dinners. Though expressed in a lighter manner, they seem sufficiently germane to accompany with advantage the statements of the text where they are inserted.

My thanks are due to the Royal Society for permission to have photographs taken specially for this book, of the Rooms of the Society; of two Pages of the Charter-book; of the Telescope made by Newton, and of the Mask of his face; of the Mace; and of contemporary Portraits in oil of the Royal Founder, and of ten Fellows of immortal fame in science.

PREFACE

For the early history of the Society I am indebted mainly to the *History of the Royal Society* compiled by Mr. C. R. Weld, a former Assistant Secretary, and published in 1848.

W. H.

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On the Title-page . A Medallion of Roger Bacon (1214–1294). Copy of an engraving on copper, made under the superintendence of Charles Babbage directly from the medal itself, by an improved form of machine invented by Mr. John Bate. The Medal forms one of a series of eminent men struck at the Royal Mint of Munich.

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The six Initial designs drawn by Lady Huggins have been in each case suggested by a leading idea in the Addresses which they severally introduce.

The Initial design at the beginning of the Fourth Address consists of a Sketch Map of part of London *c.* 1600, showing the Globe Theatre of Shakespeare, which, built in 1594, was burnt down in 1613. The Map is based upon the following authorities :—

1. London, 1543. A. van den Wyngrerde.
2. ,, 1560–1570. Ralph Agas.
3. ,, 1593. P. Vanden Keere, in *Speculum Britanniæ*, by John Norden.
4. ,, 1604. A. Ryther (*Chronicles of London.* C. L. Kingsford.)
5. ,, 1610. J. Hondius (?) in J. Speed's *Theatre of G. Britaine and Ireland.*
6. ,, 1616. N. Visscher.
7. ,, 1647. W. Hollar.
8. ,, 1658. W. Faithorne.
9. ,, Stow's *Survey*, 1st Edition ; and *History of English Dramatic Poetry and Annals of the Stage*, by J. P. Collier.

The Bear-baiting House is shown in its earlier form, though by 1600 it had probably been rebuilt in close resemblance to the Globe Theatre, and provided with a movable stage, so that occasionally plays could be acted in it.

EARLY HISTORY OF THE ROYAL SOCIETY

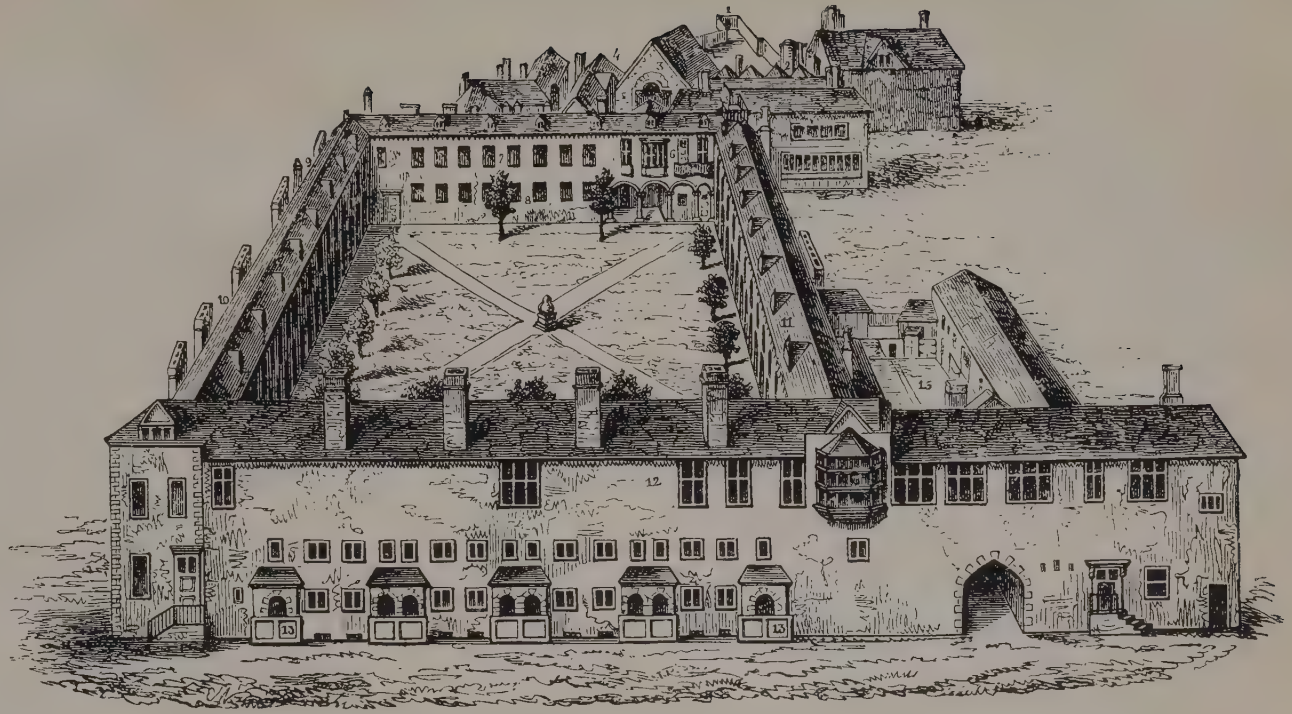
THE history, and the great work, past and present, of the Royal Society form the chief burden of the Addresses for 1903 and 1904. Sufficient information will be found there, it is believed, to furnish the reader with a not altogether inadequate conception of the circumstances of the foundation, two and a half centuries ago, of the subsequent progress, and of

the present very high position, of this great Society for the advancement of natural knowledge. Still, it may not be undesirable to supplement what has been said by a few details of the Society's early history.

The Royal Society arose out of a small club, formed about 1645, of "divers worthy persons, inquisitive into natural philosophy, and particularly of what was called the New Philosophy, or Experimental Philosophy," which met weekly in London for the discussion of "Philosophical Inquiries."

One of the distinguished members of the club was John Evelyn, who by his numerous scientific writings and his personal example exercised a powerful influence over the men of his time. The best known of his works to-day are his *Diary*, and *Sylva*, an elaborate treatise on arboriculture. A small work of his, little known at present, called *Fumifugium*, published in 1661, deals with the smoke and vitiation of the air of London, which had continuously increased since the introduction of sea-coal in the reign of Edward I. Evelyn says that the "hellish and dismal cloud of sea-coal" in his time had become so great as to make "the City of London resemble the suburbs of Hell." The sun was darkened, and travellers approaching London could smell the smoke at a distance of many miles.

He considered the smoke to be due chiefly to the chimneys of factories, and suggests as a main remedy for the state of things that all trade works evolving smoke



OLD GRESHAM COLLEGE

1 GATE INTO BISHOPSGATE STREET
2 PHYSIC PROFESSOR'S LODGINGS
3 READING HALL
4 MUSIC PROFESSOR'S LODGINGS
5 OBSERVATORY
6 GEOMETRY PROFESSOR'S LODGINGS
7 DIVINITY PROFESSOR'S LODGINGS
8 PHYSIC PROFESSOR'S ELABORATORY
9 RHETORIC PROFESSOR'S LODGINGS
10 ASTRONOMY PROFESSOR'S LODGINGS
11 SOUTH, OR LONG GALLERY
12 WEST, OR WHITE GALLERY
13 ALMSHOUSES
14 LAW PROFESSOR'S LODGINGS
15 STABLE-YARD

should, by Act of Parliament, be banished to a distance of five or six miles from London. For an improvement of the air, Evelyn suggests large plantings of aromatic trees and plants.

Evelyn quotes aptly in support of the injurious influence of smoke the words of Lucretius—

> "Carbonumque gravis vis, atque odor insinuatur
> Quam facilis in cerebrum."

In another subject of civic hygiene Evelyn showed himself to be ahead of his time, by his contention that intramural burials should be prohibited by Act of Parliament.

About 1648–1649 the club was divided; some of the members, among whom was Dr. Wilkins, afterwards Bishop of Chester, having removed to Oxford, formed themselves into the Philosophical Society of Oxford, at first meeting at Dr. Petty's lodgings in an apothecary's shop, for the convenience of inspecting drugs, and then at the rooms of Dr. Wilkins, warden of Wadham College. Dr. Wilkins became afterwards, jointly with Henry Oldenburg, one of the first Secretaries of the Royal Society; he was an inspirer of the younger men, and at that early date saw in prophetic vision navigation by submarine vessels, and travelling through the air by means of flying machines.

The Oxford Society was a powerful auxiliary to the newly founded Royal Society; the two Societies communicating to each other the principal papers of their

respective Fellows. The Oxford Society held its meetings until 1690, when it ceased to exist.

The members in London continued to meet, usually at Gresham College, with the exception of the year 1658, when the place of their meeting was made a quarter for soldiers. In 1660 the meetings were revived, and at the meeting on 28th November of that year, among other subjects was discussed the founding of a college for the promoting of "Physico-Mathematical Experimental Learning." Rules of procedure were drawn up, and a list of forty-one persons was made, who were known to those present, and were judged willing to join the new Society.

At a subsequent meeting on the 5th of December, the new Society was formed by a declaration signed by the forty-one persons named at the former meeting, together with seventy-three others, binding themselves to meet weekly when not unavoidably hindered, and to contribute one shilling weekly towards defraying necessary charges.

On the 19th December it was decided that the meetings should be held weekly at Gresham College; and on the 6th of March following, Sir Robert Moray, one of the Privy Council and of great influence with the King, was chosen President.

It would appear that, some time previously to the 16th October 1661, the Society had petitioned His Majesty to incorporate them, for on that day "Sir Robert Moray acquainted the Society that hee and Sir Paul Neile kiss'd the King's hands in the Company's Name," and is "intreated

MEETING ROOM, BURLINGTON HOUSE

by them to return most humble thanks to His Majesty for the Reference he was pleased to grant of their Petition ; and to this favour and honour hee was pleased to offer of him selfe to bee enter'd one of the Society."

In the Epistle Dedicatory to the King, at the beginning of his *History of the Royal Society* (1667), Spratt says of the founding and patronage of the Society by Charles II. : " An enterprise equal to the most renouned actions of the best Princes. For, to increase the powers of mankind, and to free them from the bondage of errors, is a greater glory than to enlarge empire, or to put chains on the necks of conquered nations."

The Charter of Incorporation passed the Great Seal on the 15th July 1662, which is therefore the date, by the elevation of the club " meeting weekly to consult and debate concerning the promoting of experimental learning " into the Royal Society, of its formal foundation. On the 29th of August the first President, Lord Brouncker, the Council and the Fellows went to Whitehall to return their thanks to His Majesty.

On the 22nd of April of the following year, 1663 a second Charter granting further privileges passed the Great Seal. In 1669 a third Charter was given, but this does little more than make a grant to the Society of lands in Chelsea (Chelsea College), but continuing the powers given by the second Charter with some slight changes. It is the second Charter which practically ensures the Society its privileges, and by which the Society has since been governed. The

second Charter provides for a Council of twenty-one, of whom ten are to be changed each year on St. Andrew's day. The election of the Council, including the President, the Treasurer, and the two Secretaries, is placed in the hands of the Fellows, as is also the election of new Fellows. Otherwise, the government of the Society, including the making of laws, statutes, and ordinances, and the transaction of all matters relating to the management of the Society and its affairs, is entrusted to the President and Council alone, the Fellows having no direct voice in these matters.

With some interruptions in 1665, on account of the Plague, and later on account of the Great Fire of London, the meetings continued to be held at Gresham College.

Gresham College, formerly the mansion-house of Sir Thomas Gresham, situated in Bishopsgate Street and extending back to Broad Street, was not only the cradle of the Royal Society, but its home until 1710.

Sir Thomas Gresham was a merchant of great distinction, the adviser of the Government in financial matters, and frequently employed in diplomatic missions; the Founder of the Royal Exchange and of Gresham College.

The representation of the College on Plate I. is reproduced from a drawing copied from an engraving in Ward's *Lives of the Gresham Professors*, which appears in Weld's *History of the Royal Society*.

A pamphlet in the British Museum, entitled *Account of the Proceedings of the Council of the Royal Society, in order*

PRINCIPAL LIBRARY, BURLINGTON HOUSE

to remove from Gresham College, gives a precise description of the commodious rooms occupied by the Society in Gresham College. "The great hall, to which the ascent from the court is by a few steps, is 37 feet long, near 20 feet broad, and 25 or 30 feet high. This spacious room is a noble entrance to the rest of the apartments of the Royal Society. The next room is about 35 feet long, near 20 feet broad, and 13 feet high; and in this the Society always met upon St. Andrew's day for their anniversary elections. The inner room for their ordinary weekly meetings is about 22 feet long and 18 feet broad. These three rooms are all upon the same floor; from the last, two or three steps convey you into the gallery, which is 140 feet long and 131–2 broad. Beyond is the Repository of their curiosities, which with the two rooms adjoining is about 90 feet long and 12 or 13 feet broad. Besides these rooms within, they have the use of a fair colonnade under the gallery and of a spacious area about 140 feet long and 197 feet broad."

In 1710, under the Presidency of Sir Isaac Newton, the Society acquired by purchase, with borrowed money, a house of its own in Crane Court, Fleet Street. On the Society taking up its abode there, the President ordered the porter to be clothed in a suitable gown, and provided with a staff surmounted by the Arms of the Society in silver; and on meeting nights a lamp to be hung over the entrance of the court from Fleet Street. After a time the porter ceased to wear a gown, but early in the last

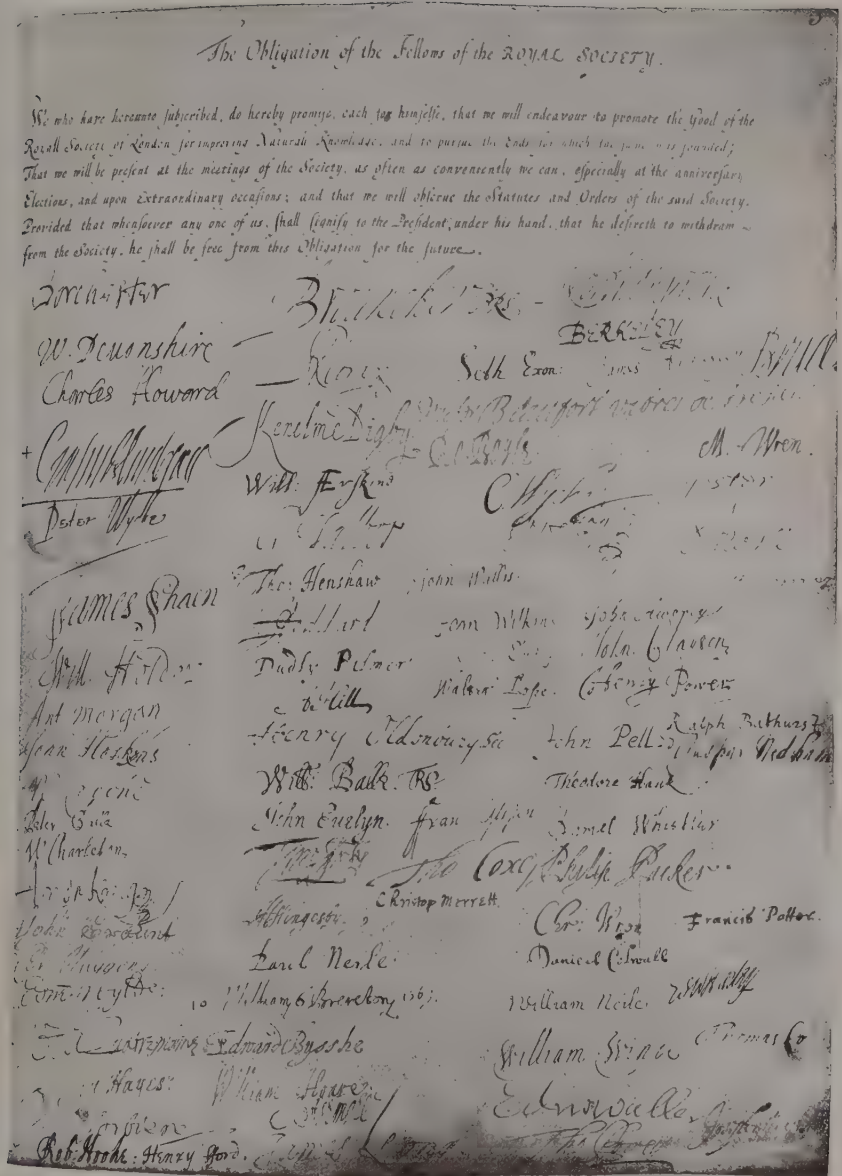
century the Council resolved that the porter should be furnished with a livery, which he still wears.

Here the Society continued to meet, until in 1780 rooms in Somerset House were placed at their disposal by the Government. In 1857, the apartments at Somerset House being required for Government offices, the Society was temporally accommodated in that part of Burlington House which is now occupied by the Royal Academy of Arts. When the new wings and the gateway were added to Burlington House in 1873, the Society took up the permanent residence which it now occupies in the east wing. (Plates II. and III.)

The Armorial Bearings granted by the Royal Founder are described in the second Charter in the following words: "These following blazons of honour, that is to say, in the dexter corner of a silver shield our three Lions of England, and for Crest a helm adorned with a crown studded with florets, surmounted by an eagle of proper colour holding in one foot a shield charged with our lions: Supporters, two white hounds gorged with crowns; to be borne, exhibited, and possessed for ever——" (Translation.)

The apt Horatian motto, *Nullius in verba*, was selected from several mottoes suggested by Evelyn. Among the others were, *Et augebitur Scientia, Omnia probate*, and *Rerum cognoscere causas*. Evelyn himself would have preferred *Omnia explorate, meliora retinete.*

The Charter-Book was opened in 1664–1665. It is bound in crimson velvet with gold clasps and corners,


The Obligation of the Fellows of the ROYAL SOCIETY.

We who have hereunto subscribed, do hereby promise, each for himselfe, that we will endeavour to promote the good of the Royall Society of London for improving Naturall Knowledge, and to pursue the Ends for which the same was founded; That we will be present at the meetings of the Society, as often as conveniently we can, especially at the anniversary Elections, and upon extraordinary occasions; and that we will observe the Statutes and Orders of the said Society. Provided that whatsoever any one of us shall signify to the President, under his hand, that he desireth to withdraw from the Society, he shall be free from this Obligation for the future.

EARLY PAGE OF THE CHARTER-BOOK

having on one side a gold plate bearing the shield of the Society, and on the other a corresponding plate showing the crest—an eagle holding a shield with the arms of England. The leaves of the book are of the finest vellum. After copies of the second and third Charters, the first page of the autograph portion contains the signatures of Charles R., Founder ; James, Fellow ; and George Rupert, Fellow.

Prince Rupert, a nephew of Charles I., a dashing soldier and cavalry leader in the Civil War, was also distinguished for his interest in science, and for his service to Art by the introduction into England, where afterwards it so greatly flourished, of mezzotint engraving, learned directly from the inventor of the process, L. von Siegen. Prince Rupert furnished Evelyn with a plate of the head of the executioner, from his splendid mezzotint engraving, of " the Executioner of St. John the Baptist " after Spagnoletto, to form an illustration to Evelyn's chapter on the new process in his monograph on the processes of engraving, *Sculptura*, published in 1662. Evelyn had received practical instruction in mezzotinting from Prince Rupert, whom he appears to regard as the inventor of the process ; he says he is preparing a full statement for the Archives of the Royal Society, where it is still preserved.

On the following page of the Charter Book, reproduced on Plate IV., beneath the Obligation which heads each leaf, are the signatures of many of the original Fellows. After that of Lord Brouncker, the first President, follow

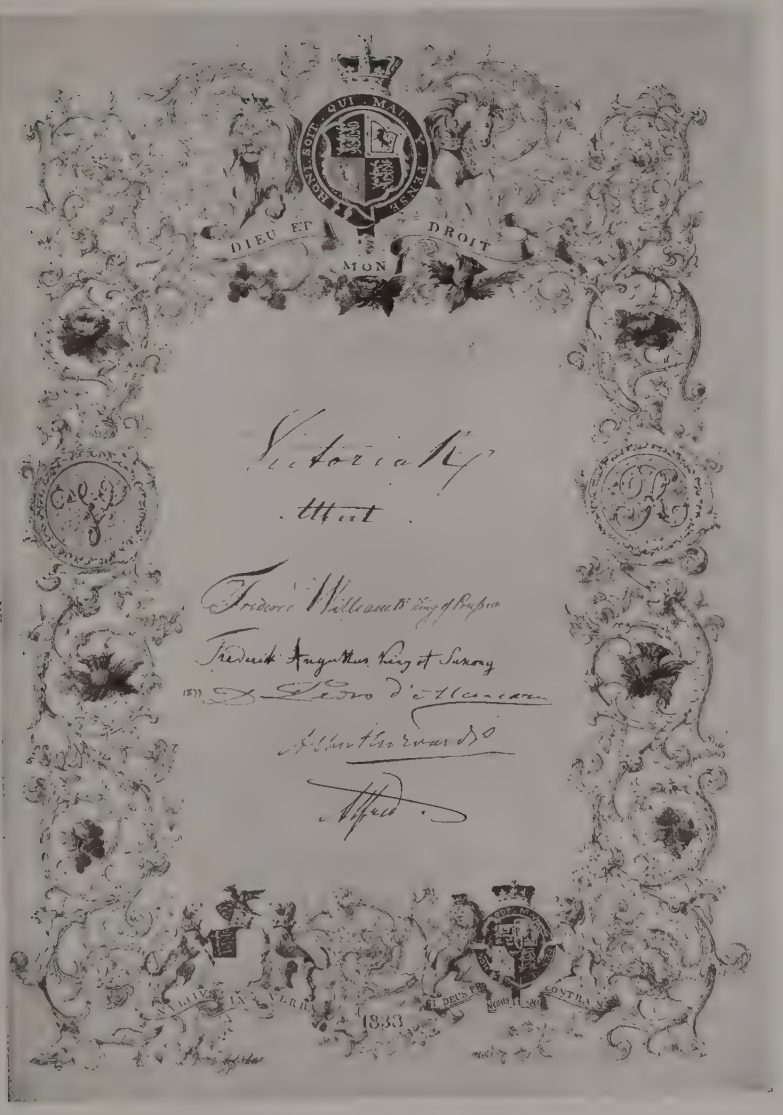
the autographs of Hooke, Boyle, Evelyn, Wilkins, Wren, and many others.

Plate V. represents a page of the Charter Book in the year of Queen Victoria's coronation, 1838. Within an illuminated border, specially prepared for Her signature, Queen Victoria has signed her name as Patron of the Society. Below are the autographs of Prince Albert, of Frederic William, King of Prussia, Frederick Augustus, King of Saxony, the Emperor of Brazil, King Edward VII. when Prince of Wales, and Alfred Duke of Connaught.

In 1671, Sir Isaac Newton, who afterwards held the office of President for the long period of twenty-four years (1705–1727), submitted to the Society an original reflecting telescope made with his own hands. (Plate VIII.)

This telescope appears to have been the first reflecting telescope actually constructed and directed to the heavens. Some six or seven years previously, Mr. James Gregory, in a book entitled *Optica Promota*, published in London in 1663, explained the theory of the kind of relecting telescope which still bears his name. As Gregory, according to his own statement, possessed no mechanical dexterity, he employed Messrs. Rives & Cox to grind a concave speculum of six feet radius, and also a small one. These were never finished, and even the tube of the telescope was not made.

Newton, having found that the angle of reflection for rays of all colours was equal to their angle of incidence, at once understood that by reflection the glaring imperfections of lenses due to the different refrangibilities of the



PAGE (1838) OF THE CHARTER-BOOK

different rays could be avoided, and a telescope of great perfection constructed, provided a substance could be found which would polish finely, and reflect a large part of the light falling upon it; and further, that the art of communicating to it a parabolic figure could be attained.

It may be mentioned that concave mirrors of polished metal had been in use very early for the magnification of near objects, probably long before Giovanni Rucellai's work on bees by this method in 1524. ("*Gli Api*, Roma, 1524.")

This telescope, made by Newton with his own hands, is nine inches long, two inches in aperture, and is stated by Newton to magnify about thirty-eight times.

In the form of reflecting telescope suggested by Gregory, the light, after having been reflected from the large concave mirror, is received soon after coming to a focus, upon a small concave mirror which sends it back through a hole in the centre of the large mirror, where the image formed is observed by means of a suitable eye-piece. In Newton's construction the light from the large concave mirror, before coming to a focus, is reflected to one side by a small plane mirror placed at an angle of 45 degrees, and passes through a hole in the side of the tube where the image is viewed. A third form of reflecting telescope was afterwards constructed by Cassegrain, in which Gregory's small concave mirror is replaced by one of convex form; as this can be placed a little within the focal distance of the large mirror, the length of the telescope is shortened

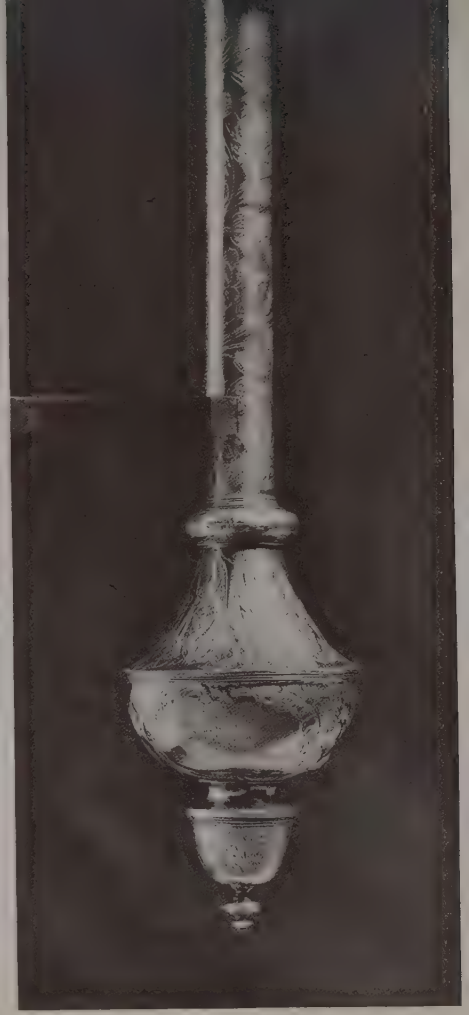
by twice the focal length of the small mirror. As, however, the image is inverted, the Cassegrain form is not suitable for viewing terrestrial objects.

It may be mentioned here that in 1785 the President, Sir Joseph Banks, at the request of Sir William Herschel, and with the sanction of the Council, laid before George III. that astronomer's scheme for constructing a reflecting telescope on Newton's plan, of the colossal dimensions of forty feet in length and four feet aperture. The King approved the project, and promised to defray the cost of constructing the instrument. The telescope was satisfactorily completed, and erected at Slough in 1789, at a cost of £4000.

The first anniversary dinner of the Society took place on the 30th November 1663. Evelyn, in his *Diary*, under the above date, says: "It being St. Andrew's day, who was our Patron, each Fellow wore a St. Andrew's cross of ribbon on the crown of his hat. After the election we dined together, His Majesty sending us venison (two does)."

In his *Diary*, Pepys writes: "I had his cross on my hat, as the rest had, which cost me 2s."

This early custom of the Fellows wearing a St. Andrew's cross of ribbon at the Anniversary Meeting, as well as the practice of the President of keeping on his hat in the chair, except when addressing the Fellows, and his wearing the large cornelian ring, bearing the Arms of the Society, bequeathed by Martin Folkes for



THE MACE

the perpetual use of the President, have been long things of the past.

It is obvious from this short sketch of the early history of the Royal Society, that it was not intended as an academy for all branches of learning, but as an Association for the promotion of what was then known as the New Philosophy, —the Improving of Natural Knowledge through a direct questioning of nature herself by means of experiment. This is clearly shown by the fuller title of the Society, given in the words of the Royal Warrant, ordering a Mace to be made for the Royal Society, of the date of 23rd May 1663.

"A Warrant to prepare and deliver to the Rt. Hon. William Lord Viscount Brouncker, President of the Royal Society of London, for improving of natural knowledge by experiment, one gilt Mace of one hundred and fifty oz. (troy weight), being a gift from His Majesty to the said Society."

An important feature of the early meetings of the Society was the performing of experiments before the members, each experiment being made for and by itself, and not as now, in illustration of a paper communicated to the Society. The importance in which these experiments were held is shown by the Society availing itself of the power granted by the Charter of "appointing two or more curators of experiments." The first curator was Robert Hooke, to whom, as joint curator, was elected Dr. Denis Papin in 1684. Papin is chiefly

known in connection with the digester which bears his name, and as a necessary adjunct to which, he invented the safety valve. Papin gave a supper, prepared by his digester, to some Fellows of the Society. Evelyn, who was present, says in his *Diary*: "The hardest bones of beef and mutton were made as soft as cheese, . . . a jelly made of the bones of beef the most delicious I have ever tasted; . . . this philosophical supper caused much mirth amongst us, and exceedingly pleased all the company. . . . I sent a glass of the jelly to my wife, to the reproach of all that the ladies ever made of the best hartshorn."

Papin observed that the boiling point of water becomes higher when under pressure from its own steam; and in 1687 he proposed to use steam as a moving power for draining mines, and later for propelling boats. His plan consisted of a cylinder in which a piston is raised by the expansion of the steam, and then is forced down by atmospheric pressure in consequence of the vacuum produced by the condensation of the steam. Papin was thus the inventor of the earliest cylinder and piston steam-engine, which afterwards took practical shape in the atmospheric engine of Newcomen.

The general scope of the early work of the Society is manifest from the Committees appointed in 1664 to take charge of some special branches of Natural Knowledge.

I. Mechanical. (69 names.)

II. Astronomical and Optical. (15.)

MASK OF THE FACE OF SIR ISAAC NEWTON

III. Anatomical. (All the Physicians of the Society.)
IV. Chymical. (The Physicians and 7 other names.)
V. Georgical. (Agriculture.) (32 names.)
VI. For Histories of Trades. (35 names.)
VII. For collecting all the Phenomena of Nature hitherto observed and recorded, and all experiments made and recorded. (21 names.)
VIII. For Correspondence.

Since 1847 the number of Fellows to be elected each year is restricted to fifteen, which is slightly in excess of the yearly average of deaths. The Council may once in two years recommend to the Society for election, not more than two persons who have rendered conspicuous service to science, or whose election might be of signal benefit to the Society.

A British Prince of the Blood Royal is eligible for immediate election.

H.M. the King, who as Prince of Wales was elected a Fellow in 1863, was pleased on his accession to become the Patron of the Society, in succession to our late revered Sovereign and Patron, Queen Victoria.

H.R.H. the Prince of Wales was elected a Fellow in 1893, and was pleased to attend an ordinary meeting of the Society on 6th February 1902, for the purpose of being formally admitted into the Society. The late Marquis of Salisbury, a Fellow of the Society, then Prime Minister, introduced His Royal Highness, who, after having subscribed the Obligation of the Charter Book, was formally

admitted by the President in accordance with the Statutes, the President taking him by the hand and saying: "I do, by the authority and in the name of the Royal Society of London, for improving natural knowledge, admit you a Fellow thereof."

There are elected from time to time, as Foreign Members, men of great eminence for their scientific discoveries and attainments, of which the number is not to exceed fifty.

The total number of the Fellows is at present 454 (January 1906).

The President is elected annually, but the Statutes contain no limitation of the number of years during which the President remains eligible for re-election. Sir Joseph Banks presided over the Society for forty-one years, Sir Isaac Newton for twenty-four, and Sir Hans Sloane for fourteen years. About thirty years ago the Council considered that it would be for the interests of the Society that a change in the Presidency should take place at intervals not greater than five years. Since that time an unwritten understanding exists, that a President will not consent to be put again in nomination after having served five years, thus practically limiting the tenure of the office to five years.

The Mace, which was made for the Society in accordance with the Royal Warrant quoted above, was received from the Master of the Jewel House in August 1663. In the first and second Charters, permission is given to the Society to have two Sergeants-at-mace to attend upon the Presi-

ORIGINAL REFLECTING TELESCOPE OF SIR ISAAC NEWTON

dent: (*duos servientes ad clavas, qui de tempore in tempus, super Presidem attendant*). The same practice exists at the Royal Society as is observed in the House of Commons: no meeting being legally held unless the Mace is placed upon the table.

The Mace is made of silver, richly gilt, and weighs 190 oz. avoirdupois. It consists of a stem handsomely chased with a running pattern of thistle leaves and flowers, this plant having been chosen as the chief ornament on account of its being symbolical of St. Andrew, the patron saint of the Society. At the upper part it is terminated by an urn-shaped head surmounted by a crown, orb, and cross. On the head are embossed figures of a rose, harp, thistle, and fleur-de-lys, emblematic of England, Ireland, Scotland, and France, and on each side are the letters C.R. Under the crown, and at the top of the head, the Royal Arms appear, very richly chased; and at the other extremity of the stem are two shields, the one bearing the Arms of the Society, the other the following inscription :—

EX MUNIFICENTIA
AUGUSTISSIMI MONARCHÆ
CAROLI II.
DEI GRA. MAG. BRIT. FRANC. ET HIB.
REGIS, &C.
SOCIETATIS REGALIS AD SCIENTIAM
NATURALEM PROMOUENDAM INSTITUTÆ
FUNDATORIS ET PATRONI
AN. DNI 1663.

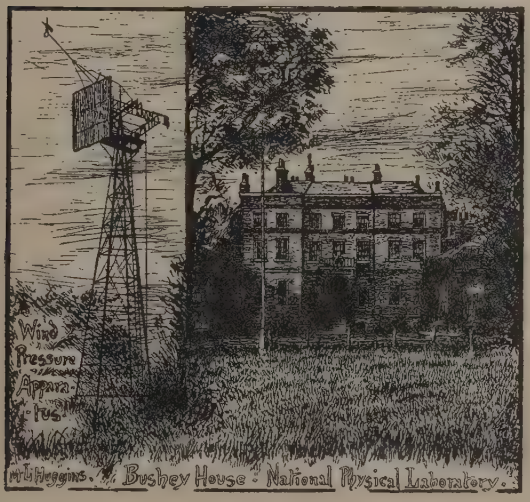
It is almost superfluous to state that there is no foundation for the mistaken belief that this Mace is the identical "bauble" turned out of the House of Commons by Oliver Cromwell. Photographs of the Mace are given on Plate VI.

I. THE SUPREME IMPORTANCE OF SCIENCE TO THE INDUSTRIES OF THE COUNTRY, WHICH CAN BE SECURED ONLY THROUGH MAKING SCIENCE AN ESSENTIAL PART OF ALL EDUCATION.

"Be famous then
By wisdom; as thy empire must extend,
So let extend thy mind o'er all the world
In knowledge," . . .

MILTON (*Paradise Regained*).

From the Address delivered at the Anniversary Meeting on December 1, 1902.



AS the living representatives of the great men who founded the Royal Society, or made it what it is, it behoves us to be very eager as to whatever concerns not only the

direct improving of natural knowledge, but also the spread of that knowledge and its influence upon the life and industry of the nation. If we contrast the culture and civilisation of the great nations of antiquity, great as they were, with the altogether fuller life of to-day, we cannot fail to recognise how completely the untold conveniences, comforts, activities possible in so many new and varied directions, the wide dissemination by means of scientific processes of forms of beauty, and the power over disease of the present time, which have not only increased the average span of life, but to a much greater extent made so much more possible to man within his short span of years, have followed directly from the great improvement which has been brought about, especially during the last century, and largely by the work of the Royal Society, in our knowledge of natural processes and of the laws which govern them.

An event, therefore, so closely associated with the direct object for which the Royal Society exists, and of so great significance and promise for a fuller recognition in the future by the Government, of the importance of scientific methods and of research to our industrial prosperity, as the establishment of a National Physical Laboratory, the opening of which has taken place since our last Anniversary, should, it seems to me, receive on this occasion more than a passing and mere formal notice, especially as the ultimate control of the Institution is vested in the Council of our Society.

SCIENCE, INDUSTRY, AND EDUCATION

The supreme value of research in pure science for the success and progress of the national industries of a country can no longer be regarded as a question open to debate, since this principle has not only been accepted in theory, but put in practice on a large scale, at a great original cost, in a neighbouring country, with the most complete success.

The Physikalisch-technische Reichsanstalt of Berlin, largely due to the scientific foresight of von Helmholtz, was instituted in recognition of the principle that all the industrial applications of science rest on the foundation of pure scientific discovery. The Institute has for its main objects—(1) The conduct of pure physical research, especially in such directions as are suggested by industrial questions ; (2) The construction and supply of electrical and physical standards ; (3) The verification of instruments of precision for scientific and technical purposes.

[This great Government Institution is now to be supplemented by a corresponding Reichsanstalt for Chemistry. Germany has long understood, what we are only beginning to learn, that the industrial developments of physics and of chemistry, on which to-day the welfare and the progress of a country so largely depend, can be adequately secured only by institutions receiving ample national support. (1906.)]

The original cost of the Institute was over £200,000, and its yearly maintenance is not less than £17,000. During the five years that it has been at work its influence upon the science and the manufacturing interests of Germany

has been most remarkable. Besides the publication of numerous memoirs of original research and of papers on technical processes, the direct results of the work of the Institute upon the industries of the country have more than justified the prevision of the founders; largely, we regret to say, to our own national loss, and to the almost complete passing to that country of the renown which was formerly ours in exact scientific measurements, and for the construction of standards and instruments of precision. So true is it, that the investment of public money in scientific research can only be compared to good seed cast into good ground, bringing forth in results a hundred, or even a thousand-fold.

Besides these more direct results, the existence of such a national Institution for physical and technical purposes cannot fail to arouse and foster the public appreciation of those scientific methods which, in education and in commerce, as well as in the industries, are the all in all of a nation's prosperity.

It is therefore with feelings of high satisfaction, shared, I am sure, by all the Fellows, that I have to record the opening in March last of a similar national Institution in this country. As was fitting to a public occasion so full of possibilities for the future wealth and power of the country, the ceremony of inauguration was performed by our Fellow, H.R.H. the Prince of Wales, who was accompanied by the Princess of Wales.

The Prince's words were weighty, and so appropriate

to this unique occasion in our country's history that I place on record here a few sentences of special pertinence and value. The Prince said :—

" I am glad that my first duty as a Fellow of the Royal Society should be to join with my distinguished brethren in opening this Institution, the direction and administration of which have been entrusted to the Society by the Government. It is also a great pleasure to assist in the inauguration of what may fairly be called a new departure, for I believe that in the National Physical Laboratory we have almost the first instance of the State taking part in scientific research. The object of the scheme is, I understand, to bring scientific knowledge to bear practically upon our everyday industrial and commercial life, to break down the barrier between theory and practice, to effect a union between science and commerce. This afternoon's ceremony is not merely a meeting of the representatives of an ancient and world-renowned scientific Society for the purpose of taking over a new theatre of investigation and research. Is it not more than this ? Does it not show in a very practical way that the nation is beginning to recognise that if her commercial supremacy is to be maintained, greater facilities must be given for furthering the application of science to commerce and manufacture ? In the profession to which I am proud to belong, there are, perhaps, special opportunities of gaining a certain insight into the general trade and commerce of the world, and of comparing the commercial vitality of the different countries.

And certainly, abroad, one finds an existing impression, which was confirmed by the experience of my recent and interesting colonial tour, that the superior technical and scientific knowledge of our foreign competitors is one reason why our hitherto pre-eminent position in manufactures and commerce is so considerably threatened. . . . They (the Government) are at present not inclined to spend more money upon equipping the laboratories. It is therefore to the liberality of the public that we must look not only for money, but for presents in machinery and necessary applicances."

The sum voted by the Government for the Physical Laboratory, an Institution second to none in its national importance, was the very modest one of £13,000 for the buildings and equipment, and an annual grant of £4000 [1] for five years in aid of the expenses of conducting the work of the Institution. It is therefore " to the liberality of the public," as the Prince pointed out, " that we must look not only for money, but also for presents of machinery and other appliances." Several donations and gifts of instruments have been received from private individuals and from manufacturing firms, but much more money will be needed if the Laboratory is to be in a position to carry out adequately some only of the chief duties of such a Government Institution ; especially the prosecutions of scientific investigations, which require more uninterrupted

[1] This sum has now been raised to £5500, and after April next will be raised further to £6000 annually. (January 1906.)

SIR THOMAS GRESHAM

BY HOLBEIN. ENGRAVED BY H. ROBINSON

time and attention on the part of the observers, or better conditions in the way of instruments and appliances than can be furnished in the laboratories of private individuals, or even in those connected with the colleges and teaching institutions of the country. A typical case in point is the great tank which, it is hoped, may be constructed in the grounds at Bushey for the purpose of determining the most suitable form of build of a ship's hull from experiments made on models drawn through the tank.

The practical limits of the application of the known laws of physics are, indeed, far from having yet been reached, and since the unexpected and brilliant discoveries of genius cannot be commanded to order, the more immediate work to be carried out in such a national Institution is probably an exhaustive study of the conditions of a more perfect adaptation of known physical and chemical laws to manufacturing processes, and to the arts of life. An instructive example may be cited from the work of the German Reichsanstalt. It was from work of this unpretentious order, and not by any direct scientific discovery, that the methods and instruments for the exact measurement of high temperatures were so developed and made available for the use of the workmen, that Germany has recently acquired its supremacy in the manufacture of porcelain.

As far back as 1660, Dr. Wilkins, F.R.S., in the Preface to his *Mathematical Magick*, says : " Ramus hath observed that the reason why Germany hath been so eminent for mechanical inventions, is because there have been public

lectures of this kind (mechanics) instituted among them, and these not only in the learned languages but also in the vulgar tongue, for the capacity of every unlettered ingenious artificer."

The supreme necessity in this country of a more systematic application of scientific methods, both in theory and in practice, to our manufactures and industries, which was so wisely insisted upon by the Prince of Wales on the occasion of his admission to the Fellowship of the Society, and again in his Address at the Opening of the National Laboratory, has since been confirmed and enforced in a remarkable way by the individual testimonies of thirteen Fellows of this Society, in the evidence which they recently gave, from their own knowledge and experience, either as teachers of science or as leaders and technical advisers in manufactories or commercial undertakings, before a Committee of the London Technical Board.

Their testimony was of no uncertain sound, but showed clearly that the Prince's words of warning, which I have quoted, were not unneeded, and that, indeed, our industries and commerce are not only in danger, but are actually passing into the hands of other countries, where scientific research is more directly cultivated under the fostering care of the State.

It seems to me the time has come when the President, on this occasion speaking on his own responsibility, should not remain silent upon a question of such urgency, and

which concerns so closely the object for which this Society exists.

The testimony of these expert witnesses was all but unanimous in showing that one of the most obvious shortcomings affecting our national industries, namely, the relatively small number of suitably trained men possessing the technical knowledge and creative skill needful for the improvement of our chemical, electrical, and engineering industries, must be regarded as a secondary symptom, following upon the smallness of the demand for such men. Further, that this smallness of demand is itself the necessary consequence of a wider and more serious state of things, which is affecting injuriously all our national activities, namely, the absence, speaking generally, of a sufficiently intelligent appreciation on the part of the leaders of the nation, whether as legislators, capitalists, manufacturers, or merchants, of the supreme importance of scientific knowledge and scientific methods, not only for the successful carrying on and improvement of all industrial enterprises, but also, and not less so, for the working out of all national problems whatever, whether of education, of economics, of hygiene, or especially of national defence in the construction of our armaments by sea and by land, and the training of our soldiers and sailors.

Here again we are face to face with a cause which is itself secondary, and dependent upon some wider antecedent state of things. Let us endeavour to get to the root of the matter.

SCIENCE, INDUSTRY, AND EDUCATION

The undoubted present state of apathy of the national mind in relation to the importance of natural knowledge, and its consequent inability to recognise how entirely and without exception, in every undertaking, success must depend upon our so acting in conformity with the laws of Nature that we have her on our side, as our ally, and not working against us, may arise conceivably from either of two causes : from a natural want of enterprise and resourcefulness inherent in the national character, or from a system of education which, relatively to the educational training of other countries, fails to develop and strengthen the qualities of mind which are needed for an adequate appreciation of science.

The former of these two possible causes may surely be dismissed at once. We need only look back in history to see how this small northern island, by its own innate energy, has come to be supreme over vast regions on all parts of the earth's surface, and is now the head of an empire which engirths the world.

We are therefore left, without power of escape, to the second alternative, namely, that it is our system of higher education which is in fault, clearly through being too mediæval in spirit. In accordance with the traditions of the past, our higher national education deals with words rather than with things ; it is based too exclusively on the memory of what is known, and too little, if at all, on individual observation and reasoning.

The evidence seems clear, that the present inappreci-

ative attitude of our public men, and of the influential classes of society generally, towards scientific knowledge and methods of thought, must be attributed to the too close adherence of our older Universities, and through them of our public schools, and all other schools in the country downwards, to the traditional methods of teaching of mediæval times. The incubus of the past makes itself felt, especially in the too strict retention of educational methods in which the first importance is given to the reproduction of knowledge from memory, to the acquiring and applying of what is already known ; with little, if any, guidance and encouragement to the undergraduate student in the direction of research and of independent reasoning.

With the experience of Germany and the United States before us, the direction in which we should look for a remedy for this state of things would seem to be for both the teacher and the student to be less shackled by the hampering fetters of examinational restrictions, and so for the professor to have greater freedom as to what he shall teach, and the student greater freedom as to what line of study and research he may select as being best suited to his tastes and powers.

We have before us in the United States an example which is worthy of our consideration. With the opening of the Johns Hopkins University in 1876, there began in the States a movement to organise advanced study, and especially research, for those who had already passed through a college course of study. In the words of Pro-

fessor Butler, of Columbia University, "the combination of collegiate and university instruction under one executive administration is distinctive of higher education in the United States, and its chief source of strength." The candidate for the highest degree, Ph.D., must spend at least two years, after obtaining his Bachelor degree, in carrying out an investigation in the field of his main object of study, and then submit the dissertation, which embodies the results of his research, preferably in printed form, to the authorities for their approval and acceptance as a condition of receiving his degree. A similar plan of university study has been pursued in Germany with success.

Into the dry bones of the present academic system of reading and examination must enter the living breath of the spirit of research,—that is to say, of the individual efforts of each mind, for itself and in its own way, to seek to extend our knowledge in the direction most suited to its powers, by means of original observation and reasoning, and aided by the imagination—it may be in the field of science, of history and literature, or of art.

One way of bringing about reform in this direction would be to make individual research an indispensable condition of proceeding to degrees higher than the B.A.

It is scarcely necessary to point out that individual training of this kind would arouse and encourage intellectual independence of thought, and especially the power of initiation and of original enterprise; and further, those creative habits of mind and that facility of resource which

FRANCIS BACON

BY P. VANSOMER. ENGRAVED BY W. H. WORTHINGTON

become daily more important in face of the complex problems of modern life, and of the severe international industrial competition of to-day.

The recent evidence before the Committee of the Technical Board of Education brought out strongly the little enthusiasm for knowledge, for its own sake, as contrasted with the devotion and interest given to athletic games, which follows from the present system of our schools.

Now the working out of some one subject by the continuous concentration of the mind upon it, which research imposes as a condition of success, necessarily begets and stimulates interest in it. The student soon becomes engrossed in his chosen pursuit. In this way enthusiasm for knowledge, for its own sake, will be awakened, and the student no longer content to go through his work perfunctorily, for the sake of passing his examination. Further, from this entering into it of a new affection, the mind of the student is no longer left empty, as is too frequently the case under the present system, to be taken exclusive possession of by athletics and games, until he comes to look upon them as a chief end in themselves, and not, as they should be regarded, as valuable means of preserving mind and body in that healthy balance which is most suitable for the severe and continued exercise of the intellectual powers.

Another secondary result, the importance of which can scarcely be over-estimated in view of the world-wide

competition of to-day, which follows from the freer and more individual educational training of the United States and of Germany, is found to be that as a rule the graduate, on leaving the University, naturally transfers the concentration of mind, which has become habitual to him through his research work, to the profession on which he enters, whatever it may be. He gives to his profession the first place in his life, bringing to bear upon it that whole-hearted devotion and enthusiasm without which, at the present day, mediocre success, at the best, is all that can be looked for.

In sharp contrast to this state of things, in this country, on the other hand, it is well known with what languid inattention and listlessness, not to say scarcely veiled contempt and disgust, only too frequently those who leave the Universities and higher schools regard the work of their profession or their official duties, and to which consequently they give grudgingly the fewest possible hours of soul-less attention. It is not to such men that we can look for successors to the great men who have passed away, or are still living, as in commerce to Rhodes and to Carnegie, or in science to Newton, Faraday, and Darwin.

In addition to the intellectual influence of a training in research upon the students themselves, the official recognition by the Universities of an original investigation of some subject, as a necessary condition of obtaining the higher academical honours, could scarcely fail to bring

about in the public mind a more appreciative attitude in regard to the importance of original reasoning and discovery, and so to a better understanding of the meaning to be attached to natural science and to scientific methods.

The first steps in the direction of true reform must be taken, it seems to me, by the Universities in the readjustment, to some extent, of the established methods and subjects of their examinations, for only in this way can the schools of the country, from the higher schools downwards, be set sufficiently free to be able to improve and enlarge their traditional teaching, which has been carried down, with but little change, from the Middle Ages.

This is not the place for a discussion of the extent to which the studies of our higher schools, and secondary education generally, require to be reformed to meet adequately the larger needs of to-day, but it is obvious that the direction in which changes should be made is in that of the development of self-helpfulness and a spirit of free inquiry, as opposed to the traditional teaching of the past.

Above all things, such a practical study of natural phenomena should become an essential part of our national teaching as would draw out and foster that noblest of our faculties, the power of image-forming in the mind, which, in its highest and productive form, does not consist simply of the reproduction of old experiences from the stores of memory, but by new combinations of them—as by a marvellous alchemy—so transmutes them as to lead to

the creation of a new imagery. This creative use of the imagination is not only the fountain of all inspiration in poetry and art, but is also the source of discovery in science, and indeed supplies the initial impulse to all development and progress. It is this creative power of the imagination which has inspired and guided all the great discoverers in science.

It is some satisfaction to know that a new section of the British Association for the Advancement of Science has been formed for the consideration and discussion in detail, of the reforms which are needed in the educational methods of the country.

It was clearly shown before the Board of Technical Education, that the so-called Modern-side teaching introduced into some of our public schools is not, as at present carried on, so successful as a means of educational training as is the traditional course. There was a consensus of opinion that boys from the Classical side of our public schools were better trained generally, and so showed a greater aptitude for acquiring and applying new knowledge, even in scientific studies, than those from the Modern side, whose smattering of scientific facts was superficial and of little value.

The explanation may lie in the comparative want of experience in the art and practice of teaching of the masters on the Modern side, together with the necessity of cramming the memory with facts and formulæ from text-books for the purpose of passing examinations. I need

scarcely say that a mere verbal knowledge of scientific facts has little value, and is altogether worthless as a means of educational training. Besides, it must not be overlooked that, as experience shows, boys of ability are not, as a rule, attracted to join the Modern side.

Taking a wide view of the whole question, it seems to be eminently desirable that the culture to be derived from classical and literary studies should, as far as possible, be retained, which would become practicable by the introduction into our schools of a much keener devotion to work, together with such improved methods of teaching languages and mathematics, as would not only increase the educational value of these studies, but also leave ample time for the teaching of science, no longer, as is now the case, as a subordinate subject to be barely tolerated, but as an integral and essential part of all education ; it being understood that such teaching of science is to take the form, as far as possible, of the study of the phenomena of Nature by direct observation and experiment.

It is obvious that with a fuller knowledge and appreciation of science on the part of the nation a complete change of its practical attitude in respect of science and science questions would necessarily follow ; for under such conditions public money would be liberally voted by the Government in aid of technical colleges and laboratories, and in response to the larger demand that would arise for them in all industrial enterprises, competent chemists, electricians, and engineers would be forthcoming in sufficient

numbers, and then, as is already the case in the United States, institutions for the teaching and advancement of knowledge would be freely founded, and liberally endowed by means of private benefactions.

In the meanwhile, much may be done provisionally by our Fellows, in their individual capacity, by stimulating and directing wisely the increased attention which is now being given to science in all departments of life, and especially in fostering and extending the many Technical Colleges and Institutions which are being established in all parts of the country.

[A primary and immediate need of this country is the putting of more science into the Education of the country. Not the teaching of the mere facts of science, which by itself is of little good, but the training of the intellect by strict scientific methods and principles.

In the coming century the race will not be to the country of the athlete, nor to the country of the classicist, but to the country whose men, having been trained under the rigorous methods of science, have the knowledge, and especially the alertness of mind, to enrich themselves out of the open and inexhaustible treasury of Nature.]

The Fellows will view with no little satisfaction the fact that the King has been pleased to recognise the importance of science being represented on the highest judicial body in the kingdom, by the appointment of two of our Fellows as Privy Councillors. When we consider that at the present time there are few important matters which

CHARLES II, FOUNDER

BY SIR P. LELY

can arise which do not include questions for the adequate consideration of which scientific knowledge is desirable, we cannot but feel some regret that on the King's Privy Council there has been hitherto no official representation of science as such, but only an incidental representation by the occasional appointment of such distinguished men of science as the Sovereign has delighted to honour.

II. THE RELATION OF THE ROYAL SOCIETY TO THE SPECIALISED SCIENTIFIC SOCIETIES.

"Let knowledge grow from more to more, . . ."
TENNYSON (*In Memoriam*).

"What is not good for the swarm is not good for the bee."
MARCUS AURELIUS (*Meditations*).

From the Address delivered at the Anniversary Meeting on November 30, 1903.

NOTWITHSTANDING the existence of three special Societies devoted to the promotion of chemical knowledge, the recent great development of the study of chemical changes and processes in which electri-

cal forces play a large part has made strongly felt the need of a new and more specialised society for the study and promotion of Electro-chemistry. The newly formed Society of Electro-chemists has taken the title—itself an omen for good—of the Faraday Society.

This recent recognition of the need of a further differentiation of chemical science, which is called for by the remarkable activity, at the present time, of workers in chemical and electrical physics, suggests to me that the present occasion would be an opportune one to consider a little carefully a subject which has been more or less before our Fellows during the last hundred years, but at no time has been more strongly present than it is to-day in the minds of some of the Fellows upon whom more directly falls the responsibility of the administration of the Society.

The matter is one which concerns so directly the advance of science in this country, that it cannot be regarded as even primarily a question of the internal organisation of the Royal Society. If further justification were needed for speaking of the subject on this occasion, I have but to quote the recently published words of one of our Fellows :—

" The progressive specialisation and differentiation of Learned Societies is known to every student of history, and it remains a grave question how long National Academies and Royal Societies can maintain their old lines of publication and of constitution." That is, as he proceeds to argue, can maintain their high position of distinction and of influence, without some reform in the direction of the

co-ordination with themselves of the existing special Societies.

The Royal Society has been itself the most active agent in bringing about, through the great increase of natural knowledge which it has effected, the present state of things, by which its own relation to the science of the country has of necessity undergone no inconsiderable change.

[In accordance with the national character of independence and individual freedom which are natural to us, the Society has remained a private body, maintained by the subscriptions of its Fellows, free from State control of every kind, accepting no pay from the Government, and no assistance except in regard of the rooms in which it carries on its work. Yet, as the representative head of the science of the country, it has always been as ready as if it were a subsidised Academy, to act as the acknowledged referee which the Government might consult with respect of any matters requiring expert scientific knowledge. This unique position of the Society among other Academies has been reached slowly during two and a half centuries, by its unwearied pursuit of truth for truth's sake without fee or reward. This position is maintained by the distinction of its Fellows, which is secured by the severe competition of selection through which the 15 Fellows annually elected have to pass, out of a list of candidates about five times as great. The annual payment in money forms but a very small part of the contribution which the Fellows are proud to make for the promotion of science. Far

heavier have been the sacrifices of time and energy which the ever-increasing activity of the Society has called for in the attendance on very frequent Council and Committee Meetings.]

At the time of the foundation of the Royal Society, and for more than a generation following, the newly born Natural Philosophy, in contradistinction to the syllogistic philosophy of the schools—or, in other words, the science of natural knowledge promoted by experiment and induction—had not advanced beyond the most general stage. The whole of our knowledge derived from direct observation and experiment of what is upon and within the earth, and of the heavens above, was then well within the fostering and the publishing power of one Society. Geology was not yet born. Electricity and Magnetism had advanced but little beyond the simplest facts as first philosophically arranged by Gilbert in the preceding century, the tercentenary of whose death occurs to-day. What then passed for chemistry was little more than the gropings of the alchemists, and the preparation of the simplest medicines. The telescope and the microscope were only just coming into use as instruments of discovery.

Through the Society's own activity, as our knowledge increased, and the number of workers in science became greater by the successive differentiation of phenomena, which is at the root of all progress, the inevitable specialisation of natural knowledge into distinct branches rapidly advanced, until at last these specialised activities found

themselves confined and trammelled by the necessary limitations of one Society. The pressure from within became gradually too great to be controlled, and could find relief only in one of two ways—by the division of the Society itself into a number of sections or branches which remained integral parts of the Society, or else by, what actually happened, the successive formation and swarming off, as the need arose, of special Societies restricted to the study and promotion of a single branch of science.

These new, but in no respect rival associations, were from the first independent bodies, which retained no connection with the Royal Society, other than the purely friendly one which necessarily followed from the leadership of the new Societies being in the hands of its Fellows.

Even as Fellows, we must place before the interests of the Society itself, those of the object for which it was founded and still exists, namely, the "promotion of natural knowledge"; we must rejoice, therefore, and indeed the more so in this case, as the interests of the Society and of science do not clash but support and promote each other, that the new and ever-increasing needs following upon the specialisation of the Fellows into groups, engaged in the study of some differentiated branch of knowledge, were not met by the inadequate and inelastic plan of sectional division of the Society itself. No arguments are necessary to-day; we have but to look at the

large membership and the great activity of the many specialised Societies to be convinced that the needful freedom and room for their rapid growth and expansion would have been altogether wanting in any plan of division of the Royal Society itself into sections for the separate study of distinct regions of natural phenomena.

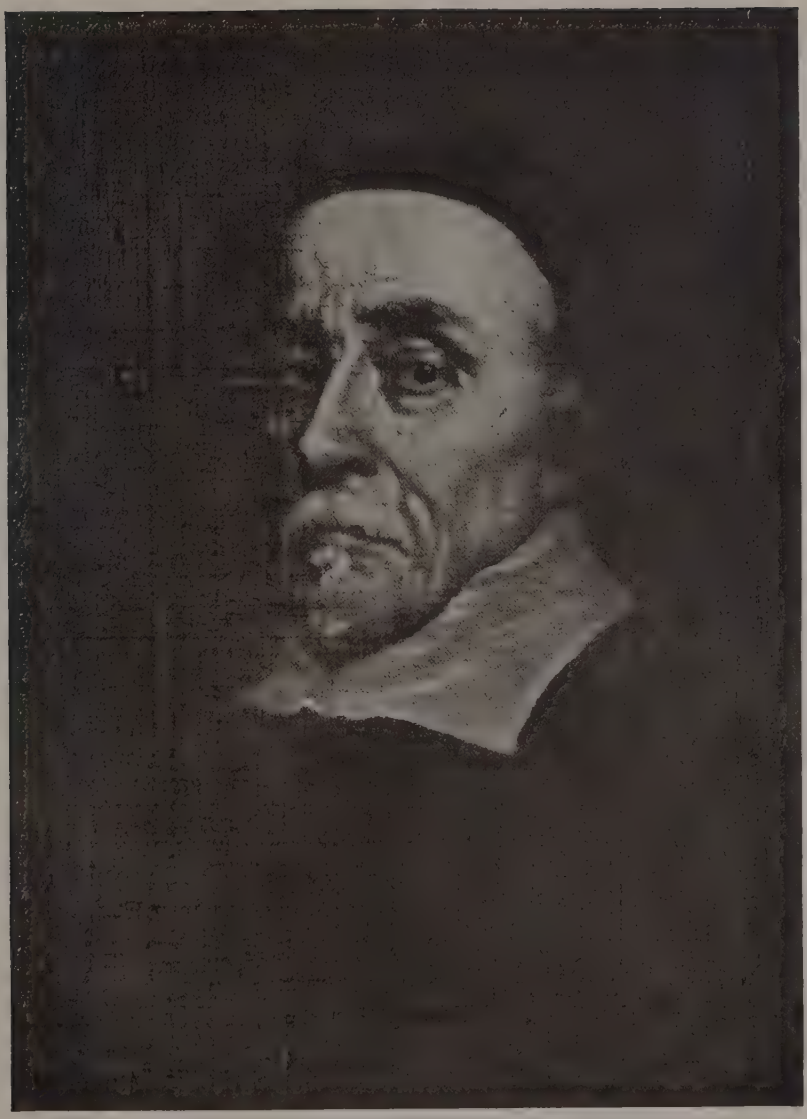
Especially in any such sectional sub-division of the Society, the necessary room for freedom of action would have been wanting in one direction of first importance, which, perhaps more than any other, has contributed to the rapid development and prosperity of the special Societies, namely, the power which these Societies possess, and which they have so largely used, of associating with themselves freely the younger men working on the same subject, who bring with them the enthusiastic energy and the power of origination which are largely present in youth ; men too young to have any claim to the membership of an Academy, and whose admission in any number to its different sections would necessarily take from its select and exclusive character, and its distinctive position as an Academy.

In the Académie des Sciences, one of the five Academies which together form the Institut de France, we have before us an illustration of a sectional Academy. L'Académie des Sciences is divided into eleven sections, each devoted to a separate branch of science. The total number of members and correspondents, however, is less than half that of the Fellows of the Royal Society. This sectional

division has not met the need for greater room for expansion as science has advanced, and has not prevented the formation of specialised Societies in Paris outside the Academy, similar to those which have grown up around the Royal Society in this country.

Indeed, the Institut de France, by its already somewhat antiquated limitations, as shown by the payment of members, by the methods of the election of its members, and especially by its close connection with and dependence upon the Government of the day, has less flexibility of adaptation to new conditions than the Royal Society, and, I need scarcely say, is not in harmony with the freer spirit of this country, or with the trend of modern thought, which is undoubtedly towards individualism; of which general tendency, though no doubt also influenced by local interests, the recent breaking up of the Victoria University into three independent bodies may perhaps be mentioned as an illustration.

The earliest instance of the sub-division or specialisation of scientific studies in this country, by the establishment of a distinct association for the cultivation of one branch of natural knowledge, took place in 1788 by the foundation of the Linnean Society under the auspices of Sir James Edward Smith, Sir Joseph Banks, and other Fellows of the Royal Society. I should mention, perhaps, that seven years earlier the Fellows of our Society who were chemists had formed an association, or perhaps more correctly a club, which met fortnightly at a coffee-



WILLIAM HARVEY
BY JAN DE REYN

house for the discussion of chemical subjects, but after a short time the meetings were discontinued.

In his Introductory Address, when the Linnean Society was formed, Sir James Smith gave as the principal reason for the institution of a new Society outside the Royal Society for the promotion of Botanical studies, that "It is altogether incompatible with the plan of the Royal Society, engaged as it is in all branches of philosophy, to enter into the minutiæ of Natural History; such an Institution, therefore, as ours is absolutely necessary." This Society, though auxiliary in its aims and objects, since it was formed for the promotion of one branch of natural knowledge, and was carried on under the leadership of Fellows of the Royal Society, existed from the first as an independent body under its own Charter.

Later on, as the inevitable outcome of the evolutionary increase of "Natural Knowledge," the Fellows who were geologists, feeling the necessity of a separate association for the fuller discussion of mineralogical and geological subjects, under the leadership of Dr. Babington, the Count of Bournon, and Sir Abraham Hume, all three Fellows of the Royal Society, instituted in 1807 another special Society after the order of the Linnean, to be called "The Geological Society of London." An attempt was made shortly after its formation to consolidate the new Society with the Royal Society as an assistant Society.

It is of interest to-day for us to consider the conditions under which it was proposed that the new Society should

remain in vital union with, or rather indeed as an integral part of, the mother Society; and also the reasons which, after discussion, decided the Fellows who formed the members of the recently instituted Geological Society to forego the obvious advantages of remaining in intimate connection with so powerful a body as the Royal Society, and to prefer to set up for themselves, and to make their own way as a wholly free and independent body.

The two principal conditions of the plan by which it was proposed that the newly constituted Society should remain permanently connected with the parent body were, —first, that the Members of the Geological Society who were Fellows of the Royal Society should constitute a distinct first class, or Council, who should be entrusted with the entire management of the Society, while the other Subscribing Members should form a second class, and be distinguished as Assistant Members. The second condition was, that this first class, or Council, should communicate regularly to the Council of the Royal Society all papers and communications received by them, in order that that body might select such papers as it pleased, to be read at its meetings, and to be printed in the *Philosophical Transactions*; the papers not so selected to be returned to the new Society, to be dealt with in such way as it might decide.

At the special general meeting of the recently formed Geological Society, which was called to consider the fore-

going plan of consolidation with the Royal Society, the following Resolution was carried : " That any proposition tending to render this Society dependent upon or subservient to any other Society does not correspond with the conception this meeting entertains of the original principles upon which the Geological Society was founded. That the propositions communicated by the Right Honourable Charles Greville, having a direct tendency to render this Society dependent upon and subservient to the Royal Society, are inadmissible."

The scientific world, as well as the Geological Society itself, have good reason to rejoice over the wise and far-seeing policy of its founders and original members, when they decided to leave the young Society free to grow and to develop its powers untrammelled by any obligations to any other body, a course which the past progress of the Society, the eminent services which it has now for nearly a century rendered to the promotion of Natural Knowledge, and the scientific distinction and the wide influence which it possesses to-day, in the fullest degree justify and confirm.

History repeats itself. Nearly ninety years later the question of the relation of the special Societies to the Royal Society, which had been raised and discussed at the time of the institution of the Geological Society, was again brought forward as one urgently needing consideration, in consequence of the large and increasing number and importance of the special Societies which had risen up about

the Royal Society, and were more or less under the leadership of its Fellows.

About ten years ago this question was formally raised by the senior Secretary, who, in a letter addressed to the President for the consideration of the Council, asked whether, in view of the development of the several special Societies, and the increase in number and importance of the independent scientific periodicals, the time had not come when changes beneficial to science and to the Societies themselves, alike in the conduct of the Royal Society and in its methods of publication, might not be introduced, based upon a formal understanding and arrangement for co-operation with the more important of the several Societies formed for the study and promotion of separate branches of science.

A strong Committee was appointed, which held numerous meetings extending over a year. Several plans for a more or less close affiliation of the principal special Societies with the Royal Society were proposed in considerable detail by members of the Committee, and these were subjected, in succession, to a very critical consideration, and to prolonged discussion at its numerous meetings.

The members of the Committee who were in favour of an organic affiliation of the specialised Societies with the Royal Society, though differing from each other as to the details of the formal arrangement by which it should be carried out, were in general agreement that it should provide an effective representation of the several Societies,

preferentially through such of their members as were Fellows of the Royal Society, upon a General Committee which could deal with the distribution between the Societies, both for reading and discussion, and afterwards for publication, of all the papers sent in to the Societies. It was suggested by some members of Committee, that the Royal Society might avail itself, with advantage, of the organisation and expert knowledge of the Councils of the special Societies, for assistance in dealing with the selection of communications for publication, and also indeed in the selection of its Fellows.

On the other hand, it was argued, and by a majority of the Committee, that affiliation in any form, even if restricted to matters of publication, involved mutual obligations, and so to some extent a sacrifice of independence alike on the part of the Royal Society and of the special Societies, which could not but be opposed to their true interests and progress, and especially would be out of harmony with the trend of modern thought, and the newer conditions coming in from the ever widening differentiation of scientific studies.

One member of the Committee, who, from the leading part he then took in the management of one of the most important of the special Societies, might claim to be regarded as representing the view which would be held by these Societies of any such small sacrifice of independence as would be necessarily involved in the obligations connected with any form of true affiliation with the Royal

Society, as the chief Society, expressed the decided opinion that "It would be impossible for his Society even to contemplate handing over any portion of its work to the Royal Society. The proper jealousy of its younger Fellows—not Fellows of the Royal Society—would render this impossible even if it were desirable on other grounds, . . . such a course would be entirely subversive of the true interests of the special Society." Then, paraphrasing the words of Lord Sherbrooke in speaking of Imperial and Colonial legislation, he went on to say that "the prosperity of the whole is best secured by making each part prosperous; that there is no conflict between the interests of the special Societies and those of the Royal Society, and that the notion of sacrificing, in however small degree, the former to the latter originates in the narrow and selfish view of a part, and not in a comprehensive view of the whole."

Another member of Committee, a professor in one of our Universities, took a very decided view of the matter in debate. "I entirely object," he said, "to allowing any other Society to take part in the administrative affairs of the Royal Society, and similarly deprecate any suggestion that the Royal Society should involve itself in the affairs of other Societies."

In their final Report, the Committee reported to the Council as follows: "The Committee gave much consideration to the general question whether or not it is desirable that the Royal Society should propose to enter into formal

HON. ROBERT BOYLE, F.R.S.

BY F. KERSEBOOM

relations with important Special or Local Societies in reference to the publication of papers and other matters. After long discussion, the Committee decided by a considerable majority that it was not desirable."

I may say in passing, that the principal outcome of the prolonged labours of the Committee was the institution of the present Sectional Committees within the Society; and also the present Standing Order that "In each year certain ordinary meetings, not more than four in number, shall be devoted, each to the hearing and consideration of some one important communication, or to the discussion of some important topic."

It is instructive to note that the deliberate opinion of a considerable majority of this recent Committee was practically identical with the resolution passed ninety years before by the recently constituted Geological Society, —namely, to the effect that affiliation, or any other form of union through which one Society should become in any respect dependent upon or subservient to any other Society, is out of harmony with the original principles which determined their separate formation, and cannot fail to trammel and so to retard their free and natural individual expansion and development.

Even if it were possible for the Royal Society to agree with the specialised Societies upon some organised plan of working together, it seems more than probable that, sooner or later, sources of friction would come in, since we have to do with associations which have been absolutely

free from their birth, and have been instituted upon principles of absolute independence.

It is not to be denied that in theory an attractive picture may be imagined in the mind of a British Imperial Scientific Association with the Royal Society at the head, and all the special Societies as independent Commonwealths so far as their internal interests are concerned, but federated with it for all purposes of advancing knowledge by research and discussion, and for the distribution of new knowledge by common methods of publication.

Such a picture, like a beautiful mirage, disappears as we approach nearer to consider in detail the practical working of such an Association of Societies.

Speaking for myself alone, the Committee were, I think, fully justified in the decision to which they came in recommending that the Royal Society, both as to its administration and its work, should remain as heretofore free from any trammels of obligations undertaken with other Societies. Whatever the views we may hold personally on this point, there can be little doubt that it would not be for the welfare of the Society to re-open, at the present time, a question which was recently settled by a considerable majority of a Committee after a very prolonged and searching inquiry.

The question which still remains open, and which, it seems to me, we may profitably consider now, is whether it would not be possible, without entering into any formal relationship with the special Societies, for the Royal Society

to take some steps to meet the pressing need of integration in respect of its own publications and those of the special Societies.

Putting aside book publication, which at the present time is very little employed for making known original work, there remain as the two chief methods for publishing newly discovered knowledge, the scientific Journal and the Proceedings and Transactions of learned Societies. To meet the demands of the present time, it is of the highest importance that the publications of scientific Societies should appear with as little delay as may be, and should be circulated directly, so as to reach them as soon as possible, among the students of the particular branch of science to which they respectively belong. In this respect the Proceedings and Transactions of the Royal Society have been up to this time at some disadvantage. Papers on the different branches of science printed in them do not circulate so fully at once among the workers in those several branches as they would do if they had been contributed to, and published by, the special Societies formed for the promotion of these several sciences.

It appears to me that an important step would be taken towards the removal of this disability, under which an Academy or Royal Society, for the promotion of all the sciences, necessarily labours; and also, at the same time, that an advance would be made in the direction of the integration of scientific publications, if the Royal Society were to offer to extend to the more important of the special

Societies the privilege already granted to and eagerly accepted by the Royal Astronomical Society, of duplicate publication in their own Memoirs of all astronomical papers which are printed in our Transactions.

A similar open offer extended to the principal specialised Societies, which they would be free to accept or to decline, of facilities for the simultaneous duplicate publication in their own Transactions of all papers communicated to the Royal Society which concern their respective sciences, would leave to them their complete independence, and not involve the Royal Society in any obligation to them which would in any way interfere with its own free administrative working.

An arrangement on these lines could be carried out at a minimum of cost to both Societies, by the simple plan that the duplicate copies of any paper required by the special Society should be struck off at one setting up in type. It would only be fair that the total expense should be divided, the special Society paying, beyond the actual cost of the printing off of its own copies, some portion, possibly a small one, of the expense of the setting up in type.

Modest as this suggestion may appear at first sight, it would, I believe, do not a little to keep the Royal Society in constant touch with its daughter Societies; and it would most certainly be to the advantage of the authors of papers, in assuring to them the immediate circulation of their communications among those, in this country and abroad, who have special knowledge of the subject and are working

in the same field. Such an arrangement for duplicate, or if necessary even multiple, publication would probably determine many scientific workers to bring their best results to the Royal Society, especially in the case of such work which, as so often occurs at the present day, concerns two or more branches of science.

The special position of the Royal Society, as head of the science of the nation, would thus be upheld without any relinquishment by the specialised Societies of their full autonomy, and indeed would be to their own advantage as auxiliary and independent bodies. The importance to the interests of the nation, as well as to the progress of science, of the maintenance of one chief Royal Society, devoted to all the sciences, is not less because of the co-existence with it of Societies devoted to separate differentiated branches of Natural Knowledge. Naturally, as consisting of the most eminent workers in different departments of the Mathematical, Physical, and Natural History sciences, the Royal Society represents on all occasions British science, both at home and abroad, and takes the place, as adviser to the Government, and as its referee on all national scientific questions; an adviser all the more trustworthy because unendowed and independent of the Government of the day.

The suggestion which I have made does not provide any remedy for one disadvantage which is inseparable from a Royal Society, namely, that in consequence of the mixed character of the papers usually read at a single sitting, a

full discussion, such as may well arise in a specialised Society, is not often possible.

In the case of the Royal Society, this absence of opportunity for discussion at ordinary meetings is to some extent provided for by the Standing Order, that in each year as many as four meetings may be set apart for the discussion of some important topic. In addition to this provision for exceptional discussion, the Secretaries do all that is in their power to have papers on the Mathematical and Physical sciences, and those on Physiology and Natural History, taken respectively at alternate meetings, but it is obvious that such an arrangement cannot be strictly carried out, because authors are always anxious that their papers shall be read with as little delay as possible, and therefore with as little interference as may be with the order in which they have been received. Any plan that might be suggested to differentiate the papers into specialised groups, so as to encourage a larger attendance of specialists at the meetings when they would be read, would be, in consequence of the longer delay in the publication of new work, neither acceptable to the Fellows nor favourable to the progress of science. Considering the highly specialised and necessarily detailed nature of the larger number of the papers received by the Society, it is a question to which more than one answer may be given, whether the subject of a paper is much advanced by a discussion founded on the abstract, which can alone be read at the meeting, and whether the time has not come when adequate

discussion, even if the presence of specialists could be secured, is no longer possible at ordinary meetings, and, indeed, can only properly take place when the full communication is in print. I may remark that the mixed character of the papers read at one meeting of the Royal Society is certainly not greater than is the case at the meetings of the French Académie des Sciences.

The adoption of the plan which I have suggested of duplicate publication of course presupposes uniformity of size of their publications with that adopted by the Royal Society, by such of the special Societies as may wish to avail themselves of the Royal Society's offer, in itself an incidental advantage of some account. If, therefore, an arrangement on these lines should meet the approval of the Fellows, the present time would be an appropriate one for the consideration whether some alteration might not be made in our own publications with great advantage to the more speedy appearance of communications of some length, as well as to some reduction in the cost, compared with the printing of them, as at present, in the Society's Transactions.

A change of great value in this direction could, I think, be made by enlarging the size of the present Proceedings, which, in consequence of their small size, are only suitable for short papers which do not require extensive illustration, to the larger size of royal octavo. The Proceedings might then take the position of being the Society's chief publication, the Transactions appearing less frequently and being

reserved for papers of exceptional length and completeness. The present reputation for superior excellence which seems to be associated with the appearance of a paper in the Transactions would disappear, and authors of papers would soon come to prefer the more speedy publication in the Proceedings in its new and enlarged form.

The cost of printing and of illustrations would be considerably reduced, and so afford funds for the increased number of papers which would probably be received by the Society under the system of duplicate publication.

If it were decided by this enlargement of size to exalt the Proceedings to a higher place in the Society's publications, it would become a matter for consideration whether it might be desirable to adopt the plan of division of subjects, which is in use for the Philosophical Transactions, and bring out the Proceedings in two series: Series A for papers which are of a mathematical or physical character; and Series B for biological papers.[1]

I have not hitherto mentioned the reduplication of the special Societies of the Metropolis by the formation of local Societies in other centres of population and intelligence, for the study and promotion of the same sciences. The separate existence of these provincial associations is fully justified by geographical reasons.

A great step in advance has been taken by the Society of Antiquaries, to which I would call attention as well

[1] The Proceedings are now published in an enlarged form, and in two series, as suggested in the text. (1906.)

SIR CHRISTOPHER WREN, P.R.S.

BY SIR P. LELY

worthy of imitation by the other special Societies of London. This Society has brought into union with itself nearly all the local archæological associations, some forty-five in number, by holding an annual Congress at its apartments in Burlington House. Each Society, while retaining its own independent individuality, co-operates with the others in matters of common interest, and one important result of their collective action is an annual classified index of all the archæological papers of the year.

[The Royal Society by its high traditions holds a unique position in the van of scientific progress, as the adviser and guide of the nation in all matters which require scientific knowledge and insight. These matters are, indeed, legion ; for all things, within and without us, are determined by the things which preceded them. Milton was not right. Chance, as high arbiter, does not govern all, though there may be times when

> "We profess
> Ourselves to be the slaves of chance and the flies
> Of every wind that blows."

In truth, law, not chance, rules all. The object set before itself by the Royal Society is to discover and to study those laws of nature which are at the root of our very life, whether personal, industrial, or national. When the Society received its Charter from Charles II., its Fellows were as men feeling and groping after truth in nature, if haply they might find it ; now they form a great army of explorers already in possession of a new world of knowledge, in the

discovery of which the Royal Society has itself played largely the part of Columbus. Contrast the view of nature which was common in the middle of the seventeenth century with that open before us to-day. One of our early Fellows tells us how trees were regarded by noblemen of his time, who considered them to be excrescences from the earth provided by Divine wisdom to enable a gentleman to pay his debts. To-day, even to a man of average culture, how rich is the concatenation of ideas which group themselves about even so familiar an object as a tree—its place in the evolution of plant life, all the physical and chemical problems associated with its growth by the assimilation of matter from the earth and air, its relation to insect and animal life, to the health and needs of man, and to conditions of climate.

Touched by science, the eye is opened to perceive behind Nature's outward aspect of form and colour, on which the artist delights to dwell, an inner world of life and relationships of not less beauty, and of infinite wonder and variety.]

III. THE ADVISORY RELATION OF THE ROYAL SOCIETY TO THE STATE, AND THE RESPONSIBLE PUBLIC DUTIES WHICH REST PERMANENTLY UPON THE SOCIETY.

"The end of our foundation is the knowledge of causes, and secret motions of things ; and the enlarging of the bounds of human empire, to the effecting of all things possible."—F. BACON (*New Atlantis*).

From the Address delivered at the Anniversary Meeting on November 30, 1904.

DURING the last few years a very large amount, increasing each year, of work outside the reading, discussion, and printing of papers, of a more or less public character, has been thrown upon the Royal Society—so large, indeed,

as at present to tax the Society's powers to the utmost. A not inconsiderable part of this work has come from the initiation by the Society itself of new undertakings, but mainly it has consisted of assistance freely given, at their request, to different Departments of the Government on questions which require expert scientific knowledge, and which involves no small amount of labour on the part of the officers and staff, and much free sacrifice of time and energy from Fellows, in most cases living at a distance.

There is little doubt that this largely increased amount of public work has arisen in part naturally from the greater scientific activity of the present day, but also, and to a greater extent, from the fuller recognition by the Government and the public of the need for scientific advice and direction in connection with many matters of national concern.

It may not be inopportune, therefore, for me to say a few words on the advisory relation in which the Society has come to stand to the Government, and to review very briefly the great work which the Society has done, and is doing, for the nation.

Among Academies and learned Societies the position of the Royal Society is, in some respects, an exceptional one. In the British dominions it holds a unique position, not only as the earliest chartered scientific Society, but in its own right, on account of the number of eminent men included in its Fellowship, and the close connection in which it stands, though remaining a private institution,

with the Government. The Royal Society is a private learned body, consisting of a voluntary and independent association of students of science united for the promotion of Natural Knowledge at their own cost.

[The identity of life of the Royal Society, as shown in its aims and in its work, has continued with a singular persistency from its foundation to the present time, though no doubt its life has been more vigorously active during some periods of its history than at others.

The Royal Society, as it exists to-day, can scarcely be more accurately described than in the words of a manuscript poem preserved in the British Museum, written soon after the Society's incorporation nearly two centuries and a half ago—

> "This noble learned corporation,
> Not for themselves are thus combined
> To prove all things by demonstration,
> But for the public good of the nation
> And general benefit of mankind."

The contemporary poet, Cowley, describes the newly incorporated Royal Society more concisely, and certainly with more poetic feeling, in a single line—

> "So human for its use, for knowledge so divine."

From its incorporation by Charles II. to the present time, the Royal Society has, with untiring energy and with steadfast aim, pursued the great object for which it was founded, "The improvement of Natural Knowledge"; and during long periods of scientific gloom has

maintained alight the lamp of pure science, when it was practically extinct in the national seats of learning.]

It asks for no endowment from the State, for it could not tolerate the control from without which follows the acceptance of public money, nor permit of that interference with its internal affairs which, as is seen in some foreign Academies, is associated with State endowment. In one particular case, in which it can receive aid without any loss of independence, the Society gratefully acknowledges its indebtedness to the State. About 1780 the Society received a communication from the Government offering to provide apartments for the Society at Somerset House; these were exchanged, in 1857, for rooms in old Burlington House; after its rebuilding, in 1873, the Society moved into the apartments which it now occupies. It should not be forgotten that nearly a century before the opening of the British Museum, in 1759, the Royal Society's Museum, or Repository as it was called, enjoyed the prestige of being regarded as the most important Museum in London, and must have been of great use to men of science, and have aided materially in promoting and disseminating the knowledge of natural history. The apartments offered to the Society at Somerset House were quite insufficient in capacity and in number to receive the Society's Museum, and in consequence this collection, which had been carefully maintained not only from the scientific side, but also with reference to the commercial value and importance of the foreign objects received,

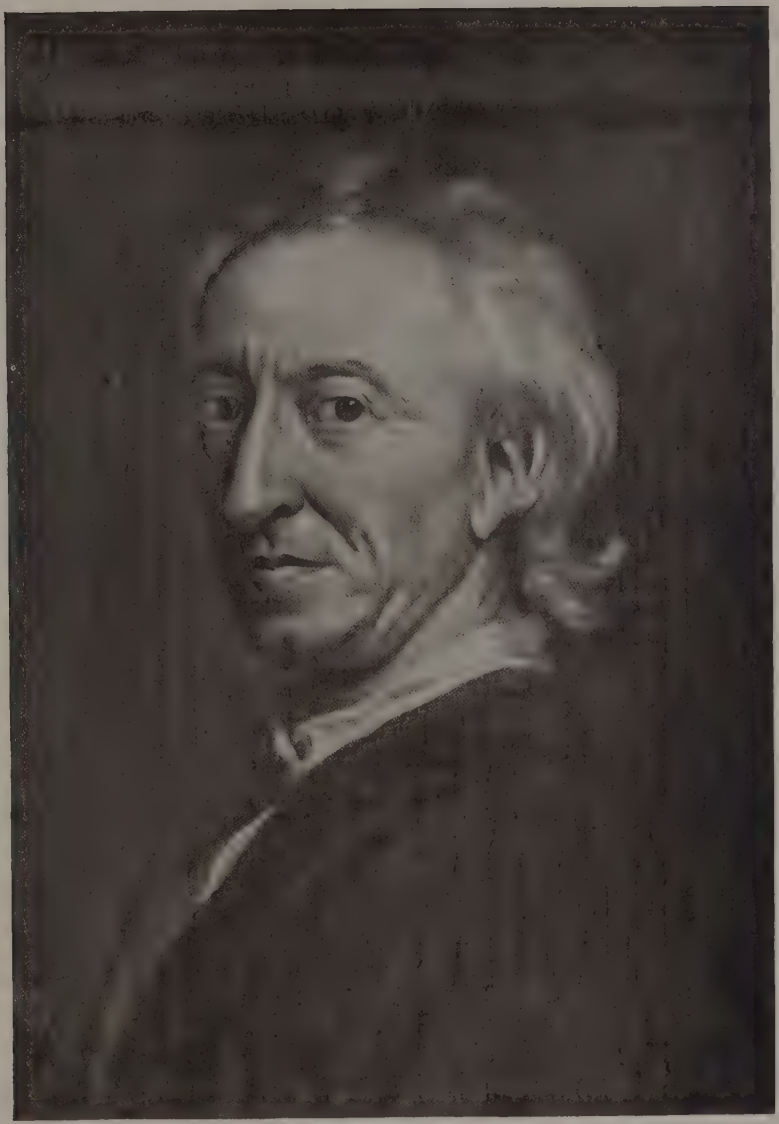
especially of the valuable zoological specimens frequently sent by the Hudson's Bay Company from their territories, was presented by the Society to the nation, a not unworthy acknowledgment, on the Society's part, of the Government's gift of apartments. This collection has not been kept separate, but is now hopelessly dispersed among the thousands of specimens which crowd the halls of the British Museum. Some specimens, however, in comparative anatomy, preserved in the Museum of the College of Surgeons, are duly entered in the catalogue as having belonged originally to the Royal Society's Museum.

Besides the grant of apartments in Somerset House, and subsequently in Burlington House, the Society has received no pecuniary support from Government, nor assistance of any kind, with one exception to be mentioned farther on, beyond the grant by Charles II., shortly after its incorporation, of Chelsea College and the lands appertaining to it ; a gift which proved much less valuable than appeared from the parchments. Claimants at once came forward for portions of the estate, and the property was in so unsettled a state as to title, and so much out of repair, that after much money had been spent on repairing the College, and great exertions made in vain to procure a tenant, the President was authorised to sell the estate to the King for the sum of £1300 ; the Council voting their thanks to him for " thus disposing of a property which was a source of continual annoyance and trouble

to them." To the extent of this sum the Society's funds were enriched by the royal gift.

The grants of £4000 and £1000 now received annually by the Royal Society from the Government are not applicable to its own needs, but are placed in its hands in trust for grants in aid of the prosecution of scientific research, and of the publication of scientific papers; indeed, with the exception of part of the publication grant, are so far from being of the nature of a State bounty, that the careful administration of these grants brings no light burden upon the Society.

It may not be generally known that the Royal Society just missed becoming a richly endowed Society. Charles II.'s interest in the young Society did not end with the grant of a Charter of Incorporation, for in 1662 he addressed a letter, written with his own hand, to the Duke of Ormonde, then Lord Lieutenant of Ireland, recommending the Royal Society for a "liberal contribution from the adventurers and officers of Ireland for the better encouragement of them in their designs." That is to say, in the new settlement in that country, on the Restoration, of the confiscated estates of such persons as by the King's declaration were disqualified. The Royal Society had but a poor chance, notwithstanding the King's letter, of coming in for a portion of these so-called "fractions," when so many high families were cheated of their rights, and the Duke's own estates, through his methods of adjudication, increased from £7,000 to £80,000 per



JOHN EVELYN, SEC. R.S.

BY F. KERSEBOOM

annum. Sir William Petty, in a document preserved in the archives of the Society, estimates the value of the lands granted by the King to the Society, but not received by them, "as a great matter, but I know not what."

It is on record that the non-fulfilment of the King's generous intentions towards the Society did not damp the philosophic ardour of the Fellows; indeed, it is a question on which opinions may widely differ whether the rich endowment of the Society, almost from its very birth, would have increased its scientific success. We must not forget that, in the case of institutions as well as of individuals, a powerful and healthy stimulus to the exertion needful for success arises from the necessity of coping with and overcoming difficulties, whether of a monetary or other kind. In no small degree was due to the personal favour with which Charles II. regarded the Society the exceptional position it early took up, and which it still holds to-day, of a private institution supported and controlled from within, which at the same time is acknowledged by the State as the authoritative national representative of science in this country, and from time to time consulted as such.

The first royal act which distinctly gave this representative character to the newly chartered Society appears to have been the King's declaring his pleasure, on the 15th October 1662, "that no patent should pass for any philosophical or mechnical invention until examined by the Society." This personal recognition by the King of

the national position of the Society was followed and confirmed a few years later by a request from the Department of the Admiralty, for assistance from the Royal Society in raising some ships sunk off Woolwich. The Council replied that, though they would have great pleasure in affording all assistance in their power by advice, the want of funds rendered it impossible for them to provide the necessary machinery.

From that time down to the present, the Royal Society, while remaining a purely private institution for the promotion of Natural Knowledge, has been regarded by the Government as the acknowledged national scientific body, whose advice is of the highest authority on all scientific questions, and the more to be trusted on account of the Society's financial independence; a body which, through its intimate relations with the learned Societies of the Colonies, has now become the centre of British science. The Society's historical position and the scientific eminence of its Fellows have made it naturally the body which the scientific authorities of foreign countries regard as representing the science of the Empire, and with which they are anxious to consult and to co-operate, from time to time, on scientific questions of international importance.

On their part, the Fellows of the Royal Society, remembering that the promotion of Natural Knowledge is the great object for which it was founded and still exists, and that all undertakings in the home and in the State, since they are concerned with Nature, can be wisely directed

and carried on with the highest efficiency only as they are based upon a knowledge of Nature, have always recognised the fundamental importance of the Society's work to national as well as to individual success and prosperity, and their own responsibility as the depositaries of such knowledge. They have always been willing, even at great personal cost, ungrudgingly to afford any assistance in their power to the Government on all questions referred to them which depend upon technical knowledge, or which require the employment of scientific methods. In particular, the Society has naturally always been eager to help forward, and even to initiate, such national undertakings as voyages of observation or of discovery of any kind, or for the investigation of the incidence of disease, which have for their express object the increase of Natural Knowledge.

At the same time, as the Society is dependent upon the voluntary help of its Fellows, whose time is fully occupied with their own work, the Society may reasonably expect the Government not to ask for assistance on any matters of mere administration that could be otherwise efficiently provided for. The hope may be expressed that in the near future, with increased official provision in connection with the recognition of science, the relation of the Society to the Government may not extend beyond that of a purely advisory body, so that the heavy responsibilities now resting upon it, in respect of the carrying out of many public undertakings on which its advice has been asked, may no longer press unduly, as they certainly do at present, upon

the time and energy of the Officers and Members of Committees. The Society regards this outside work, important as it is, as extraneous, and therefore as subordinate, and would not be justified in permitting such work to interfere with the strict prosecution of pure natural science as the primary purpose of the Society's existence, upon which, indeed, the Society's importance as an advisory body ultimately depends.

The array of national undertakings of which the Society has been wholly or in part in charge, or to which it has given advice or assistance from time to time, is so very great, that any attempt to point out, even in broad outline, the more important of the directions in which the Society's influence has been actively employed for the public service must necessarily be fragmentary and very incomplete. On this occasion it is not possible to do more than to give, in a few sentences, a rapid presentation of a few typical examples of the Society's public work.

It must be borne in mind that the bare statement in a few sentences of the public work accomplished by the Society fails altogether to bring before the imagination an adequate conception of the large amount of free labour ungrudgingly given by those Fellows who composed the several Committees to which the work was entrusted.

Going back to the first century of the Society's existence, the work done for the National Observatory at Greenwich may be fairly taken as typical of the Society's outside activity at that time. It is not too much to say that the

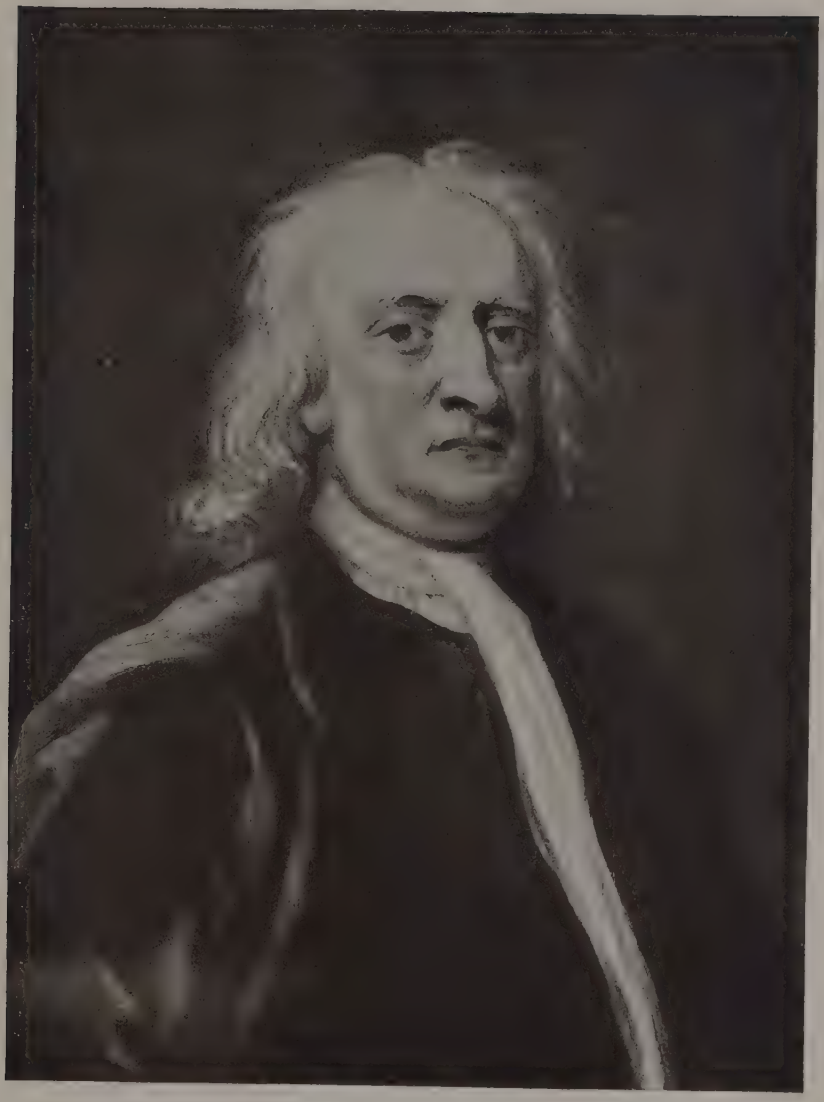
Observatory owes, in no small degree, its early efficiency and the high position it soon reached, to the advice and the energetic action on its behalf of the Royal Society. The Observatory, at the time it was placed, in 1710, by Queen Anne in the sole charge of the Society, was without instruments, except such as Flamsteed had himself supplied. Immediately on taking charge, the Society appointed a Committee which visited Greenwich, and as a result sent in an application to the Ordnance Office, but at the time unsuccessfully, for the new instruments which were absolutely essential for properly carrying on the work of an observatory. The little interest taken by the Government of that day in science is manifest from the answer received from the Ordnance Office, "that they had never been at any charge for instruments, but only for repairing the house and paying Mr. Flamsteed's salary." The Society persevered, and when in 1720 Halley succeeded Flamsteed, was successful in persuading the Government to provide a few of the more necessary instruments. At a little later date the Society induced the Government to expend £1000 on instruments, to be constructed by Graham and Bird. When George III. came to the throne, he re-appointed the Society as sole Visitors, and ordered the Astronomer Royal to obey the regulations drawn up by the Council, and commanded the Master General of Ordnance to furnish such instruments as the Council should think necessary for the Observatory. In the list of these instruments is mentioned a ten-foot telescope of

Dollond's "new invention." Further, it was in answer to a petition from the Royal Society that the King gave orders for the printing of the Observations made at the Observatory. At a later date the Society called on the Government to advance funds to establish magnetical observatories at Greenwich, and in various parts of the British dominions, with the result that in a few years no fewer than forty magnetical establishments were in full activity.

In connection with the Observatory may be mentioned the considerable share which the Society took in bringing about the important alteration of the calendar, known as the Change of Style, which took place in 1752. The Bill was drawn up by Peter Davall, the Secretary of the Society, aided and supported by Lord Macclesfield, who became President the same year. The change was approved and assisted by the actual President, Martin Folkes. The feeling of the people was so strongly against the change, that the illness and death of Bradley, who as Astronomer Royal had assisted the Government with his advice, which took place not long afterwards, were popularly attributed to a judgment from Heaven.

Very brief must be the mention of some of the other works in the public service which were carried out at a no small cost of labour to the Fellows of the Society.

About 1750, the Lord Mayor of London, two of the Judges, and an Alderman, having died in one year from jail-fever caught at the Old Bailey Sessions, the Society



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was called upon for advice and assistance. A Committee was appointed to investigate the wretched state of ventilation in jails. A ventilator, invented by one of the Committee, was erected in Newgate, reducing at once the number of deaths from eight a week to about two a month. Of the eleven workmen employed to put up the ventilator, seven caught the fever and died.

At the request of the Government, Committees were appointed to consider the best form of protection of buildings, and, later on, of ships at sea, from lightning.

The Society took a very active part in the measurement of a degree of latitude, afterwards in the length of a pendulum vibrating seconds in the latitude of London, and in the comparison of the British standards with the linear measure adopted in France. A Committee was appointed to compare the Society's standard yard with that of the Exchequer. Later, in 1834, when the standard yard was lost in the destruction by fire of the Houses of Parliament, a Commission (all the members of which were Fellows of the Royal Society) was appointed to consider the steps to be taken for the restoration of the standards.

It was at the instance of the Council of the Society, who petitioned George III. for the necessary funds, that the King gave his consent to a geodetical survey in 1784, with the immediate object of establishing a trigonometrical connection between the Observatories of Greenwich and Paris. The work, under General Roy, for which the Copley Medal was awarded to him, served as a basis for

the operations of a more extensive nature, embracing a survey of the British Islands, which were commenced in 1791.

Since its foundation the Society has taken an active part in many important expeditions for scientific and geographical exploration, and for magnetical and astronomical observations,—in some cases taking the initiative by memorialising the Government for the necessary assistance by grants of money, the use of ships, or otherwise. Among these may be mentioned the expeditions sent out for the observation of the transits of Venus in 1761 and in 1769.

The importance of Antarctic exploration, for which the recent National Expedition has been promoted jointly with the Royal Geographical Society, was fully understood by the Royal Society nearly a century and a half ago. In 1771 an expedition having for its principal object the exploring of high southern latitudes, with the view of ascertaining the existence of a great Antarctic Continent, was strongly and successfully urged on the Government by the Society. The expedition under Captain Cook sailed the following year. On its return three years later, after having circumnavigated the globe, the Copley Medal was awarded to Captain Cook for the means he had taken to preserve the health of his crew.

In 1817 a letter was addressed by Sir Joseph Banks, on the part of the Council, to Lord Melville, urging that an expedition of discovery should be sent out for determin-

ing the practicability of a North-West Passage. The Lords of the Admiralty gave orders for the fitting out of four vessels, and invited detailed instructions from the Royal Society for the guidance of the officers. The Council recommended Colonel, then Captain, Sabine to proceed with the North-West Expedition, and Mr. Fisher to accompany the Polar one. The expedition failed to procure geographical results of importance, but it was far from fruitless, for the magnetical observations brought back by Sabine were an addition of real value to physical science.

This expedition was followed by another two years later under Parry, which resulted in the discovery of the Strait called after Barrow, then Secretary to the Admiralty.

A later Polar Expedition, under Captains Parry and Ross in 1827, was promoted by the Royal Society, and brought home valuable magnetical observations, which were printed in the Society's Transactions.

At home, it was through the Society's influence that Dr. Maskelyne, the Astronomer Royal, was able to make observations in Scotland for the purpose of deducing the density of the earth. Dr. Hutton undertook the laborious task of working up the data, the whole expenses being borne by the Society.

These few examples, inadequate as they are, must suffice on this occasion to remind us of the many labours during two centuries and a half undertaken by the Society for the public good. I pass now at once to some of the

many objects of public concern which are at the present time either directly promoted or assisted by the Society.

The establishment in this country of a National Physical Laboratory, for the purpose of bringing scientific knowledge to bear practically upon the industries and commerce of the nation, was due in no small measure to the action of the Society, and has certainly thrown upon it much additional permanent responsibility. The necessity for such an Institution in this country, which was clearly shown by the marked influence of a similar Institution on the improvement of technical science and the manufacturing interests of Germany, had been already strongly advocated by individual Fellows,—in particular, by Sir Oliver Lodge at Cardiff in 1891, and Sir Douglas Galton at Ipswich five years later; but the first practical step towards its realisation was taken by the Council in 1896, when they decided that the Royal Society should join the British Association and other kindred Societies in a Joint Committee, under the Chairmanship of the President of the Royal Society, to take such action as they find desirable.

In the following year this Committee waited upon Lord Salisbury, who was then Prime Minister, and as a result a Treasury Committee was appointed by the Chancellor of the Exchequer, with Lord Rayleigh as Chairman, to consider the desirability of establishing a National Laboratory. That Committee, after hearing

witnesses and visiting Germany, reported strongly and unanimously in favour of such a national Institution. In 1898 a communication was received from the Treasury expressing "the hope that the Royal Society will be willing to add to the already great services rendered by them to the Government and public of the United Kingdom, by consenting to undertake the new responsibilities now sought to be imposed upon them" in connection with the new Institution. The Council accepted the important trust, under which the "ultimate control of the Institution is vested in the President and Council of the Royal Society, who in the exercise thereof may issue from time to time such directions as they may think fit to the General Board and Executive Committee." The income and all other property is vested in the Royal Society for the purposes of the Institution. The Laboratory, which was formally opened by H.R.H. the Prince of Wales in March 1902, has already made remarkable progress under its energetic Director. During the present year the attention of the Prime Minister has been called to the very great importance to the national industries of an immediate grant for new buildings and a more adequate instrumental equipment, and of a larger annual endowment.

It is not too much to say that men of science of all countries are under no small obligation to the Royal Society for their Catalogue of Scientific Papers which have appeared in all parts of the world since the beginning of the last century. This great work, to which immense

labour has been given gratuitously and without stint by Fellows during the past forty years, will be carried down to the close of the century, and will consist of two parts: an Authors' Catalogue, and a Catalogue of Subjects. Encouraged by a donation from Mr. Andrew Carnegie, and the noble liberality of Dr. Ludwig Mond and other Fellows, the Council decided to proceed with the completion of the Catalogue, in the hope of further donations from Fellows and others as the work advances.

It was obvious that to continue permanently to prepare and publish catalogues of the rapidly increasing output of scientific literature would be wholly beyond the means of any one Society, and was an undertaking so vast as to require organised international co-operation for success. In 1893, a letter, signed by seventeen Fellows, was addressed to the President, asking that steps might be taken to provide for the continuation of the Society's Catalogue from the beginning of the century by adequate international co-operation. A Committee was appointed, which reported in favour of an international conference on the subject. Three conferences were held successively in 1896, 1898, and 1900. It is scarcely possible to convey an adequate conception of the arduous and prolonged labours of these conferences, and of the numerous meetings of committees held in connection with them. The Society may well feel great satisfaction that a work of such magnitude, and of so great moment to all scientfic workers, which was initiated by itself, was taken up with such remarkable

accord by the scientific world. The organisation consists mainly of a Central Bureau in London under the Royal Society, in connection with Regional Bureaus, established in thirty countries for collecting material in the form of catalogue slips, and transmitting them to the Central Bureau. The Royal Society has taken upon itself practically the financial responsibility of the undertaking, making contracts in its own name with a printer and a publisher, the latter undertaking the technical duties as agent for the Society, which is its own publisher. The first year's issue of the Catalogue has appeared, dealing in twenty-one volumes with the seventeen sciences decided upon by the Conference.

The International Association of Academies, the realisation for the first time of the great scientific idea of a Universal Academy, open without restriction of language or of country to every nation under heaven, owes its establishment to the initiative of the Royal Society. In 1897 the Royal Society was invited to send representatives to a Conference of a Union of German Academies and Societies which met from time to time. The Society sent delegates, but declared that the Society's permanent adhesion to any such association must be conditional on its being made truly international in character. The principle of an international association of learned Societies suggested by the Royal Society was accepted, and a conference was held at Wiesbaden in 1899 for the purpose of taking steps for the formation of such an association. Statutes were

drawn up and arrangements made for the holding of the first General Assembly in Paris in 1901.

The primary objects of the Association are the initiation and promotion of scientific undertakings of general interest and of universal concern to mankind, especially of such matters as are outside the power of a single Academy, and require for their promotion the assistance of the Governments represented by the Association. Indirectly, by its triennial General Assemblies in different countries, it should become an instrument of no mean power for the promotion of the brotherhood of mankind, and for hastening the day

> "When the war drums throb no longer, and the battle flags are furl'd,
> In the Parliament of man, the Federation of the world."

The Association, as now constituted, consists of twenty Academies and learned Societies of Europe and America. The second General Assembly of the Association was held this year in London under the auspices of the Royal Society, which, as directing Academy, had had general charge of the conduct of its business during the last three years. The Section of Letters met under the direction of the newly founded British Academy.

The Society has accepted heavy responsibilities at the instance of the Government in respect of the control of scientific observations and research in our vast Indian Empire. In 1899 the India Office inquired whether the Royal Society would be willing to meet the wishes of the Indian Government by exercising a general control over the

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scientific researches which it might be thought desirable to institute in that country. A standing Committee was appointed in consequence by the Council, for the purpose of giving advice on matters connected with scientific inquiry, probably mainly biological, in India, which should be supplementary to the Standing Observatories Committee, which was already established at the request of the Government as an advisory body on astronomical, solar, magnetic, and meteorological observations in that part of the Empire.

An investigation, onerous indeed, but of the highest scientific interest and of very great practical importance, has been carried on by a series of Committees, successively appointed at the request of the Government, for the consideration of some of the strangely mysterious and deadly diseases of tropical countries. In 1896 a Committee was appointed at the request of the Colonial Secretary, to investigate the subject of the Tsetse Fly disease in South Africa. Two years later, Mr. Chamberlain, Secretary of State for the Colonies, requested the Society to appoint a Committee to make a thorough investigation into the origin, the transmission, and the possible preventives and remedies of tropical diseases, and especially of the malarial and "Blackwater" fevers prevalent in Africa, promising assistance, both on the part of the Colonial Office and of the Colonies concerned. A Committee was appointed, and under its auspices skilled investigators were sent out to Africa and to India. In the case of the third Com-

mittee the Society itself took the initiative. An outbreak in Uganda of the disease, appalling in its inexorable deadliness, known as "Sleeping Sickness," having been brought to the knowledge of the Society, a deputation waited upon Lord Lansdowne at the Foreign Office, asking him to consider favourably the despatch of a small Commission to Uganda to investigate the disease. He gave his approval, and a Commission of three experts, appointed on the recommendation of the Committee, was sent out to Uganda, £600 being voted out of the Government grant towards the expenses of the Commission.

The investigations in tropical diseases, promoted and directed by these Committees, have largely increased our knowledge of the true nature of these diseases, and, what is of the highest practical importance, they have shown that their propagation depends upon conditions which it is in the power of man so far to modify, or guard against, as to afford a reasonable expectation that it may be possible for Europeans to live and carry on their work in parts of the earth where hitherto the sacrifice of health, and even of life, has been fearfully great. A general summary of the work already done on Malaria, especially in regard to its prevention, and also on the nature of "Blackwater" Fever, has been published in a parliamentary paper, which records Mr. Chamberlain's acknowledgment to the Royal Society for its co-operation in the work undertaken by the Colonial Office. Our Reports on Sleeping Sickness up to this time form four parts of a separate publication giving evidence in

support of the view that this deadly disease is caused by the entrance into the blood, and thence into the cerebro-spinal fluid, of a species of Trypanosoma, and that these organisms are transmitted from the sick to the healthy by a kind of tsetse fly, and by it alone ;—Sleeping Sickness is, in short, a human tsetse fly disease.

In 1897 the Council was requested to assist the Board of Trade in drawing up Schedules for the establishment of the relations between the Metric and the Imperial Units of Weights and Measures. A Committee was appointed, which, after devoting much time and attention to the matter, drew up Schedules which were accepted by the Board of Trade and incorporated in the Orders of Council.

A Coral Reef Committee has been in active existence for some years, and has directed the attempts to pierce, by boring, the atoll of Funafuti, towards the expenses of which grants have been made by the Council. The results of the work have appeared in a large volume, giving a description of the whole core from the points of view of the naturalist and the chemist ; and a list, with critical remarks, of the species of animals and plants collected.

Soon after the reports were received of the appalling volcanic eruptions and the loss of life which took place in the West Indies in 1902, the Council received a letter from Mr. Chamberlain to ask if the Society would be willing to undertake an investigation of the phenomena connected with the eruptions. The Council, considering that such an investigation fell well within the scope of the objects of

the Society, organised a small Commission of two experts, who left England for the scene of the eruption eleven days only after the receipt of Mr. Chamberlain's letter; the expenses being met by a grant of £300 from the Government Grant Committee. Six weeks were spent in the Islands, including Martinique, by the Commission, which was successful in securing results of great scientific interest. A preliminary report was published at the time, and a full report has since appeared in the Transactions.

Time forbids me to do more than mention the successive expeditions sent out by the Society, conjointly with the Royal Astronomical Society, for the observation of total solar eclipses; and the onerous work thrown upon the Society for several years in connection with the National Antarctic Expedition, undertaken jointly with the Royal Geographical Society, which has this year returned home crowned with success as regards the latter; but the Society's labours are not at an end, for the prolonged and responsible task of the discussion and publication of the scientific results of the Expedition is still before them.

In addition to the numerous undertakings, of which some examples have been given, in which the influence and work of the Society have been exercised for national or public objects, there are a number of other ways in which the Society makes its influence continually felt and of which the responsibilities are always with it. The Society is represented by the President, as an *ex-officio* elector, in the election of eight scientific Professorships

at the Oxford University, and one Professorship at Cambridge. The President is also *ex-officio* a trustee of the British Museum, and of the Hunterian Museum, and a Governor of the City and Guilds of London Institute. The Society has a voice, through a representative Fellow chosen by the Council, on the governing bodies of the Imperial Institute, the Lister Institute of Preventive Medicine, Sir John Sloane's Museum, Eton, Rugby, Harrow, Winchester, and four other public schools, and the Advisory Board for Military Education. The Council of the Society are electors of four members of Lawes' Agricultural Trust, and are nominators of the members of the Meteorological Council. The Society is represented by the President and six of the Visitors on the Board of the Greenwich Observatory. One of the four sets of copies of the Standard Weights and Measures is held in custody by the Society. There is also a Committee for systematic work in Seismology.

To the Royal Society is entrusted the responsible task of administrating the annual Government Grant of £4000 for the purpose of scientific research, and a grant of £1000 in aid of the publication of scientific papers.

In addition to these permanent responsibilities, which are always with the Society, its advice and aid are sought from time to time both by the Government and by Scientific Institutions at home and abroad, in favour of independent objects of a more or less temporary character, of which, as examples, may be taken the recent action of the Society

for the purpose of obtaining Government aid for the continuation through Egypt of the African Arc of Meridian, and for the intervention of the Government to assist in securing the fulfilment of the part undertaken by Great Britain in the International Astrographic Catalogue and Chart.

Upon the present Fellows falls the glorious inheritance of unbounded free labour ungrudgingly given during two centuries and a half for the public service, as well as of the strenuous prosecution at the same time of the primary object of the Society, as set forth in the words of the Charters : " The promotion of Natural Knowledge." The successive generations of Fellows have unsparingly contributed of their time to the introduction and promotion, whenever the opportunity was afforded them, of scientific knowledge and methods into the management of public concerns by Departments of the Government. The financial independence of the Royal Society, neither receiving nor wishing to accept State aid for its own private purposes, has enabled the Society to give advice and assistance which, both with the Government and with Parliament, have the weight and finality of a wholly disinterested opinion. I may quote here the words of a recent letter from H.M. Treasury : " Their Lordships have deemed themselves in the past very fortunate in being able to rely, in dealing with scientific questions, upon the aid of the Royal Society, which commands not only the confidence of the scientific world, but also of Parliament."

In the past the Royal Society has been not infrequently greatly hampered in giving its advice, by the knowledge that the funds absolutely needed for the carrying out of the matters in question in accordance with our present scientific knowledge would not be forthcoming. Though I am now speaking on my own responsibility, I am sure that the Society is with me if I say that the expenditure by the Government on scientific research and scientific institutions, on which its commercial and industrial prosperity so largely depend, is wholly inadequate in view of the present state of international competition. I throw no blame on the individual members of the present or former Governments; they are necessarily the representatives of public opinion, and cannot go beyond it. The cause is deeper,—it lies in the absence in the leaders of public opinion, and indeed throughout the more influential classes of society, of a sufficiently intelligent appreciation of the supreme importance of scientific knowledge and scientific methods in all industrial enterprises, and indeed in all national undertakings. The evidence of this grave state of the public mind is strikingly shown by the very small response that follows any appeal that is made for scientific objects in this country, in contrast with the large donations and liberal endowments from private benefaction for scientific purposes and scientific institutions which are always at once forthcoming in the United States. In my opinion, the scientific deadness of the nation is mainly due to the too exclusively mediæval and classical

methods of our higher public schools, and can only be slowly removed by making in future the teaching of science, not from text-books for passing an examination, but, as far as may be possible, from the study of the phenomena of Nature by direct observation and experiment, an integral and essential part of all education in this country.

[The Royal Society is an institution which has not only devoted itself to the prosecution of pure science, and has encouraged and helped on the application of science to national undertakings, but has raised the standard of thought and of living of the nation. With the growth of the Society since its foundation, how greatly have the thoughts of men been widened by the process of the suns. The fairy-tales of science, now so familiar, make us the more eager for the further progress which the coming years shall bring, especially for more knowledge of the relation of the phenomena of Nature to ourselves, and for a wider philosophy in the light of which the domains of the living and of the non-living shall be seen to lose themselves in a common realm of harmony and light; in a word, for the coming vision of the world and all the wonder that shall be. For wonder is a fruit of natural knowledge as well as its root. Alas! for us creatures of a moment—science moves slowly, creeping on from point to point. Still, at no time in the past has the pace of scientific progress been so rapid; at no time so imminent the clearing away of the mist of the unknown from many points of strategic importance for the conquest of more knowledge of the

inner relations of things. On one central eminence, dominating alike the past, the present, and the future, science has for some years firmly entrenched herself—the position that through all the ages the cosmos has advanced, and is still advancing, by a process of orderly evolution. In the domain of the living the fact of progress by means of evolution was finally established by our illustrious countrymen Darwin, and his prophet Huxley. In heredity and variation, the great discovery of Mendel, in the hands of one of our medallists of to-day, promises to bring the biologist nearer to his main quest, the fundamental nature of living things. In physics, only a few years ago Professor J. J. Thomson took by storm the outworks of the central citadel of Nature—the chemical atom. His later brilliant attacks, aided by the new artillery of radio-active radiations, may be said to have carried the keep itself. This stronghold of matter was found to be a place of positive electrification in which swarms of negative electrons are winging their mazy rounds. Material mass gives place to the electric mass of moving electric charges. On this view the chemical elements, each with its individual properties, but all falling into family groups according to a periodic law, have their origin in differences in the number of the electrons and in the figures of their giddy dances, whirling within the atom. Material nature becomes simplified into electricity and ether—or, is it only ether? Passing from the atom to the heavens, within the memory of those living, science has taught us so to read sunbeams and star-

beams as to enable us to apply the methods of the laboratory to the heavenly bodies. By means of their radiations alone we discuss their chemical constitution and their orbital and other motions, which were before unknowable. By each discovery the vision of the world has become more glorious, the wonder of it more amazing, while chambers and palaces of Nature still unexplored remain the exhaustless heritage of all coming generations. Are our theories more than artificial conceptions, mental pictures co-ordinating a large range of facts and guiding us to new facts? Have we approached even within telescopic view of the reality of things? What sustains the uniformity of Nature? What is behind the obvious trend and direction of development of the cosmos? Was there a beginning? Will there be an end? Or, do

> "The torrents of her myriad universe
> Fly on to clash together again, and make
> Another and another frame of things
> For ever"?

Science is silent; but with eyes aflame looks forward to the coming day

> "When light shall spread . . .
> Thro' all the seasons of the golden year."]

Part of London c. A.D. 1600 showing the Globe Theatre of Shakespeare & the Bear Garden.

IV. ON THE PROFOUND INFLUENCE WHICH SCIENCE, REPRESENTED BY THE ROYAL SOCIETY, HAS HAD UPON THE LIFE AND THOUGHT OF THE WORLD; AND THE PLACE OF SCIENCE IN GENERAL EDUCATION.

"Wisdom and knowledge shall be the stability of thy times."—ISAIAH xxxiii. 6.

"What is put into the schools of a country comes out subsequently in the manhood of the nation."—STEIN.

From the Address delivered at the Anniversary Meeting on November 30, 1905.

AT the last anniversary I occupied a few minutes in bringing to your remembrance some of the more important occasions on which the Society in the past had initiated, supported, or given advice about scientific questions in connection with the State; and, at the same time, I called attention to the large number of responsible public duties which to-day rest permanently upon it, and by which, either through departments of the State or through other public bodies, the Society makes its influence felt strongly for the good of the country.

To-day I wish to speak of the profound influence which the discoveries of science, in great part the work of Fellows

of this Society, have had upon the general life and thought of the world, especially during the last fifty years.

The untold material benefits which science has conferred upon civilised mankind are too familiar to need mention ; they are always with us, from the world's news upon our breakfast table to our sun-bright evenings. There are, however, other benefits more subtle and less obvious, but not less real and certainly not of less price—the wider range of thought and the greater intellectual freedom which have followed upon modern scientific discovery.

I am justified, surely, in saying that the average way of thinking on all subjects has been as much altered and elevated by the researches and writings of men of science, as have been the common conditions of living. The contrast in what and how we think to-day, as compared with the day on which the Society received its Charter, in 1662, is as great as it is in how we live and travel.

The changes which have taken place in the scope and mode of national thought, especially during the last fifty years, have been brought about mainly in two ways : by a breaking down of inherited prejudices and of traditional opinions through the results of scientific discovery ; and secondly, by the freer and more direct methods of thinking which have followed from the experimental study of Nature.

The Royal Society was itself a chief practical outcome of a new spirit, which, during the generation preceding its foundation, had arisen at Oxford and elsewhere, and was

stirring into life the dry bones of a rigid and antiquated philosophy. Scholasticism, already in decay, was slowly losing its hold upon the more active minds, who refused to accept any longer as final the traditional hypotheses and syllogistic methods of the schools in the interpretation of natural phenomena. There was growing slowly a conviction of the necessity, in the study of Nature, of an appeal to Nature herself by means of direct experiment.

Of the great men who had come into this state of mental unrest, the most original and creative was Francis Bacon, who, by the unequalled power and eloquence with which he summed up and put into a connected system the new ideas which were in the air, gave so great an impulse to the newer mode of thinking, as rightly to have received the name of the "Father of experimental philosophy." His immediate success was due, however, in no small part, to the circumstance that the time was ripe for the great changes in the way of studying Nature, which in his writings he so powerfully expounded and enforced.

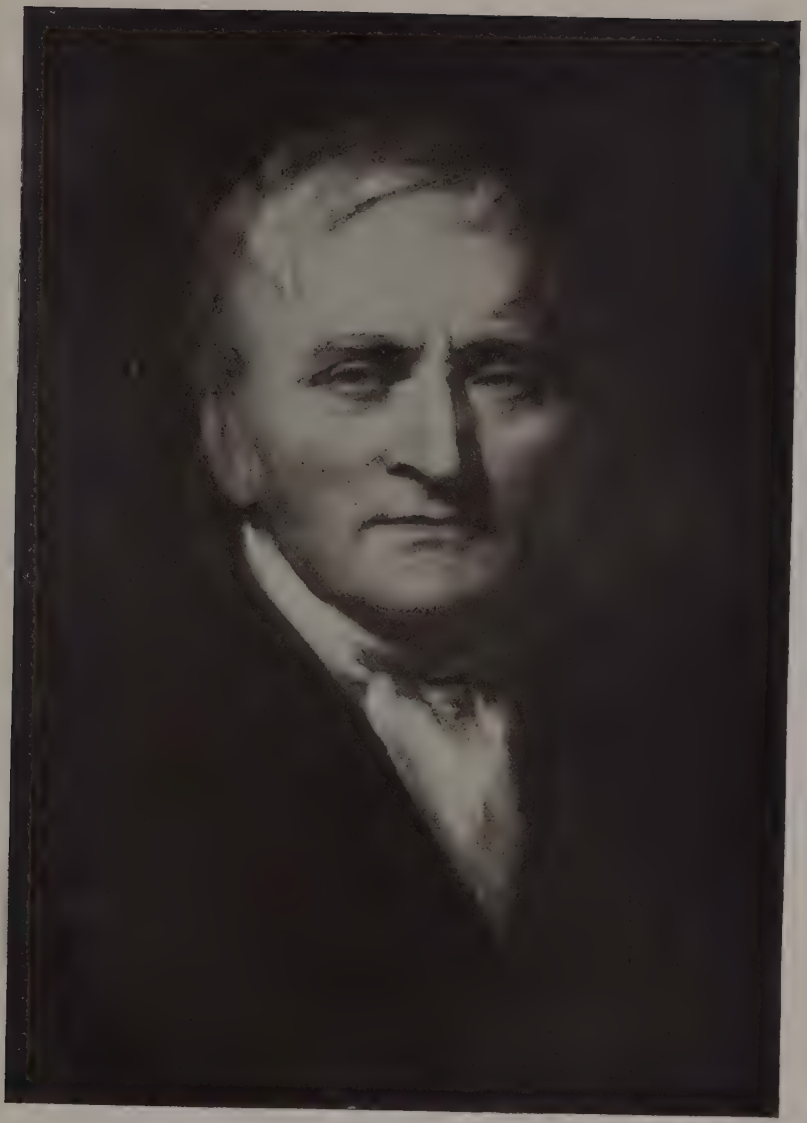
I must pause for a moment to say how very unfortunate in this respect was the lot of his great, if not greater, namesake, Roger Bacon, the "Doctor Mirabilis," as he was properly named, who, born out of due time, exerted but little influence on contemporary thought.

Let us not forget that it was Roger Bacon who, 300 years before the time of "large-browed Verulam," saw clearly that the study of Nature could only be successfully prosecuted and advanced by means of experimental

research, and so gave it the highest place as *Domina omnium scientiarum*. The reasons which he gave for his exaltation of experiment might have been written yesterday, so modern is his standpoint. "Experimental science," he says, "has three great prerogatives over all other sciences: it verifies their conclusions by direct experiment; it discovers truths which they could never reach; and it investigates the secrets of nature, and opens to us a knowledge of the past and of the future."

To return to Francis Bacon: his philosophy was summed up in the words *Imperium hominis*, the great destiny of man as the ruler of Nature; and he saw that man's rightful sovereignty over Nature could only be attained through the slow and laborious acquirement of a true understanding of Nature. Bacon looked upon Nature as an overwhelmingly complex congeries of phenomena; and as a *filum labyrinthi* by which man might slowly find his way through its mysteries to all knowledge, he put forward and expounded in the *Novum Organum* his new method, *spes est una in inductione vera*.

It must not be forgotten that Bacon's induction is something more than the traditional induction of the logicians, and practically became a new method, since it includes the elimination of the non-essential. It is no disparagement of the great and revolutionary work of Bacon to acknowledge that the discoveries of science during the last two centuries and a half have not been won by an exclusive following of his method. For example, he



JOHN DALTON, F.R.S.

BY B. R. FAULKNER

assigns no proper place to the use of the trained imagination in scientific experiment, though, indeed, he speaks of the procedure from one experiment to another as an art, or a learned sagacity. Further, there is in his system no sufficient appreciation of the deductive method of reasoning.

On these grounds questionings have made themselves heard, and in some quarters rather loudly, whether Francis Bacon has a right to the high position usually accorded to him in the history of experimental science. We shall probably not go far wrong if we allow ourselves to be guided by the views of Bacon taken by his immediate intellectual successors, the great men, Boyle, Evelyn, and others, who had the chief part in founding the Royal Society. We find them reflected in the Ode to the Royal Society, composed, at the instance of Evelyn, by the contemporary poet Cowley. He likens Bacon to a modern Moses, who led the chosen people to the promised land of knowledge of Nature, though he himself did not enter, and only viewed it imperfectly from afar. The fine engraving by Hollar which forms the frontispiece to the large paper edition of Spratt's *History of the Royal Society*, published in 1667, the design of which was furnished by Evelyn, contains two principal figures: the first President of the Society, Lord Brouncker, is on one side of the bust of the Royal Founder, and on the other is Bacon with the title of *Artium Instaurator*.

[Surely no one of the founders of the Society would have

been bold enough to forecast the marvellous "improvement of natural knowledge" which, under the influence of the Society, has been won by methods of experiment and induction. To some of the founders would have been not less surprising the conditions under which this great work has been accomplished. The master minds of that age were more or less under the influence of the ideas represented by the monastery and the cell—that is to say, an Academy in which the Fellows live apart from common life, and are secluded from its cares and interests. We find these ideas in Bacon's *Solomon's House*, in his classical fable of the *New Atlantis*; even more strongly in the generous plan for a scientific college submitted to Boyle by the noble-hearted Evelyn, and in Cowley's proposition for a college of experimental philosophy. Now the great work of the Society has been done, not in the seclusion of an Academy, but, so to speak, in the world. The Fellows have not been supported in a learned leisure by the Society, but taking their full part in the work of the world, of their own substance maintained the Society. Under these circumstances, there was no need to limit the number of Fellows to the 27 fathers of Solomon's House, or to Cowley's 20 philosophers. The Society's 450 Fellows, all taking their part in the common life of the nation, are a great power, each Fellow acting upon the men around him, and so the Society, like a leaven, imbuing the mind of the people with the vivifying ferment of natural knowledge. And I think that upon the Fellows themselves, the living in constant

touch with the needs and activities of common life may well act as a stimulus to that alertness of mind which is most favourable to scientific progress and discovery. Still, after all, in principle the older men were in the right, for the idea underlying the academic grove and the cloister, and for which these external conditions of life were then considered necessary—namely, simplicity of living and absolute devotion to the pure quest of truth, unswayed by the glittering tinsel of social distinction and success—are precisely those conditions of being which find access to Nature's most secret places. Surely a man who is able to devote himself to the study of Nature has as good a position as the world is able to confer. The Society has never before stood so high as at the present time with regard to its scientific activity, and to the number and quality of the papers published in its Proceedings and Transactions.]

If the methods and discoveries of science can exert the large influence on general thought which I have claimed for them, some explanation may be needed of the great slowness of any incoming, to an appreciable extent, of a wider and freer spirit during the first centuries of the Royal Society's existence. Two hundred years went slowly by without any very marked change in this respect showing itself in the intellectual attitude of the people. The public mind, on all questions which have to do with man's position in relation to Nature, still slumbered on under the narcotic influence of traditions which were regarded as too sacred to be open to discussion. Still,

during these 200 years the leaven of the open mind of scientific research was silently at work, for each true student of Nature became, among those about him, the source of a new and living influence. The fact was that, during all that time, there was no real mental contact, no true understanding, between the man of science and the average man of education. The mind trained to receive without questioning the teaching of traditional authority, and the mind eager to find out new truth in the spirit of the Society's motto, *Nullius in verba*, had little in common ; they were often even mutually repellant. It could hardly be otherwise ; there was no popular scientific press, and in the halls of the schools the drone of monotonous repetitions from memory of knowledge sanctioned by authority was never broken in upon by the jubilant eurekas of experiments, however simple, or of individual observation of Nature.

What in the intellectual world would correspond to a thunderbolt or an earthquake was needed to awaken and transform the slumbering age—and it came. In the early years of Queen Victoria's reign the accumulated tension of scientific progress burst upon the mind, not only of the nation, but of the whole intelligent world, with a suddenness and an overwhelming force for which the strongest material metaphors are poor and inadequate. Twice the bolt fell, and twice, in a way to which history furnishes no parallel, the opinions of mankind may be said to have been changed in a day. Changed, not on some minor points standing alone, but each time on a fundamental position which, like a key-

stone, brought down with it an arch of connected beliefs resting on long-cherished ideas and prejudices. What took place was not merely the acceptance by mankind of new opinions, but complete inversions of former beliefs involving the rejection of views which had grown sacred by long inheritance.

I need scarcely say that I am speaking of two scientific discoveries, following each other at no great interval of time about the middle of the last century, and both due mainly to the work of Fellows of the Society. The first discovery was the evidence from geology for the great antiquity of the earth, as opposed to the all but universal belief of the time, and then evidence for the great age of man. The second discovery, of a not less revolutionary import, was the doctrine of organic evolution by the principle of natural selection, which brought about a complete change of opinion as to the position of man himself in relation to Nature.

If I speak strongly, it is because I lived through that period, and my recollections are still vivid of the fierce fury of the storm of opposition with which both these innovations of thought were at first assailed. It seems to me that these signal victories of new knowledge, gained by experimental methods of research over views in which for generations men's minds had been fast riveted by tradition and authority, placed natural science, for the first time, in its true position, as within its own sphere the absolute authority to which all must bow. Up to that time science

had been on sufferance ; welcomed, indeed, when it contributed to the supply of man's material needs, as by the steam engine and the railroad ; dallied with, and sometimes smiled at, when her conclusions did not clash with what men had been taught to regard as unassailable truth : but rejected with scorn, and her prophets vilified with epithets borrowed from the darkest times of mediæval persecution, whenever, in the spirit of the Society's motto, she dared to utter words which were not in agreement with inherited beliefs. Then, to some extent, the true position of natural science was acknowledged, and she came into her own—the crown and sceptre of authority which are her right—as, to repeat Roger Bacon's words, *Domina omnium scientiarum*.

Ever since that time, notwithstanding cavillings here and there, of which the echoes are still audible, natural science has taken a truer place in relation to the general thought of the age. Her position of supreme authority has been recognised, and each year strengthened, by the unbroken series of brilliant discoveries which have distinguished the last half-century, and which have impressed themselves so much the more deeply on the public mind because they have been lavishly accompanied by practical applications and inventions, which have increased, to an extent almost beyond words, the power, richness, and happiness of human life.

This is not the place to discuss in full how fruitful have been in all directions of human thought, and so

THOMAS YOUNG, F.R.S.

BY H. P. BRIGGS, AFTER SIR T. LAWRENCE

for the progress of mankind, the two great revolutions of opinion of which I have been speaking, especially the one that came a little later, and will for all time be associated with the name of Charles Darwin, of which the innate vitality is so great that it has already grown into a great tree of knowledge bearing all manner of fruit. It is indeed true that before Darwin the idea of a continuous development, alike in the physical and biological worlds, had formed the basis of speculations in many quarters; but this conception, being contrary to current belief, had left no impression on the general mind. It was not until Darwin's works appeared that the new evidence was perceived to be overwhelming in favour of the view that man is not an independent being standing alone, but is the outcome of a general and orderly evolution. It follows from this view, that the principle of evolution must henceforth take a guiding place in the consideration of all problems relating to man, to the history of his fundamental convictions and opinions, as well as to all social and economic questions of the present and of the future.

To the open eye all the world is indeed a stage, the boards themselves having been laid by an earlier evolution, on which, through ages, the drama of the orderly evolution of living things has been going on. Through the revelations of palæontology we can, in imagination, become spectators of the scenes of the earlier acts of the slow progress of events leading up to the entrance upon the stage of man himself. Then in archæology and history,

as in magic mirrors, we can see re-acted the early scenes of the final act (which is still in progress), in which man plays the principal part. The strident brass was softened when Nature's orchestra modulated into the melodic and more joyous *leit-motiv* heralding the coming on of man. In the later scenes, Intelligence has come on to take the leading part hitherto played by Brute Force, and man has brought with him into the drama the new characters of Pity, Mercy, and Charity.

Henceforth the dominant power in the world is brain, controlled by the emotions of the heart ; and the highly trained intelligence the chief factor of success in all departments of individual and national enterprise.

One of the most important and fruitful results of the intellectual upheaval which followed upon the two great discoveries of science, of which we have been speaking, is the almost unlimited freedom of personal belief which we enjoy to-day. The older Fellows, who, like myself, lived through that eventful time, will not have forgotten the narrow and bigoted spirit which then prevailed. Though without the name, and unsupported by the terrors of rack and stake, in fact and in deed an inquisition was still in power. The reproach of heresy was freely used, and those who dared to think for themselves, and exercising their private judgment to swerve from the current opinions sanctioned by antiquity, were made to feel how heavy could be the social penalties enforced by the spirit of persecution.

Experimental science came as the liberator of men's minds, setting free from the prison-house of conventional beliefs the spirits which had been lying for generations in the bonds of the dogmas of past ages. Slowly men came to acknowledge that the arbitrary authority of names, and of systems of belief however greatly venerated, must give way when science speaks with the reasonable authority of experiment and observation. This new form of authority, to which men were coming to yield an unquestioning obedience, unlike the dogmatic teachers at whose feet they had sat, does not claim finality for its opinions. It is the distinctive glory of experimental science that it is for ever seeking further truth in all directions, and is always ready to change its opinions into agreement with the newest knowledge, whithersoever it may lead, which it is able to wrest from Nature by experiment. There are many striking recent examples, of which I will mention only the unexpected phenomena of radio-activity, and the acute earnestness of the biologist of to-day in his quest after the fundamental nature and scope of living things.

In this way, during the last half-century, under the freer conditions of general thought introduced by natural science, men gradually became accustomed to wide differences of personal opinion, and so no longer feared them; there arose slowly the spirit of modern toleration and the recognition of the right of every man to judge for himself on all matters of opinion,—that is, to allow himself to be guided by his reason, which demands sufficient evidence

for belief. Already a remarkable change in the way of looking at things in all departments of thought has been brought about. To an extent before unknown, each man now thinks for himself, and is no longer content to accept sluggishly the current beliefs of his time, but seeks to bring all things to the touchstone of experiment and experience.

Perhaps I am speaking a little prematurely, and painting the present under the illumination of the golden radiance of the dawn of a still freer future, for even to-day we are reminded in the press, from time to time, that the spirit of persecution is not yet dead.

Another direction in which, during the last half-century, the public mind has been powerfully influenced by the discoveries and the methods of science, is in a change of attitude, in all matters of opinion, towards truth, by putting truth for her own sake in the first place as its main quest.

I do not for a moment suggest that consciously the desire for truth does not take the first place in all honest hearts. All the other great departments of human interests, however, as politics, economics, theology, and philosophy, are broken up into sharply divided schools of thought, of which the differences of opinion are accentuated by the jealousies and the intolerance of party feeling. In the great majority of cases, men find themselves by the lot of birth and early education among the adherents of one or other party, and nearly always come

unconsciously to identify the issues of that particular party with truth itself. With the most honest intentions on the part of the speakers, the reasoning which is heard in Parliament, or from public platforms, is almost always one-sided from the warping influence of party ties and issues.

In direct opposition to this narrowness of thought, which views all subjects through the distorting mirage of party prejudice, stands the absolute freedom of mind of the man of science, who knows, or ought to know, nothing of party, and stands with open arms to welcome truth in however strange or unexpected guise she may present herself. In his writings the man of science has no lower aim than the diffusion of truth so far as it is known, and no desire to make converts to any opinion or party. As opposed to the finality of party opinions, he proclaims that truth is but very partially attained by man on any subject, for we can see truth only imperfectly, as she appears altered by the perspective of our own standpoint. The scientific attitude of mind is no less than antipodal to that of the ordinary party man, wrangling for his own particular shibboleth.

Following upon greater freedom of private opinion, and the desire for truth rather than for party success, has grown up the greater fearlessness in suggestion, and in the acceptance of new views, which is undoubtedly characteristic of the present age, and stands in strong contrast to the conventional timidity of half a century

ago. This fearlessness has been won chiefly through the widening of human thought by natural knowledge, by which the prejudices inherent in human nature, or which have come down by inheritance, have been greatly weakened, if not yet overcome. The fearless courage of change of opinion required by experimental science is safeguarded by the demand which she makes in all cases for sufficient evidence from observation or experience.

To sum up, the influence of science during the last fifty years has been in the direction of bringing out and developing the powers and freedom of the individual, under the stimulation of great ideas. To become all that we can become as individuals is our most glorious birthright, and only as we realise it do we become, at the same time, of great price to the community. From individual minds are born all great discoveries and revolutions of thought. New ideas may be in the air, and more or less present in many minds, but it is always an individual who at the last takes the creative step and enriches mankind with the living germ-thought of a new era of opinion.

All influences, therefore, and especially all laws and institutions which tend to lose the individual in the crowd, and bring down the exceptional to the level of the average, are contrary to the irresistible order of nature, and can lead only to disaster to the individual and to the State.

I should not omit to mention the marvellous secondary effects of scientific discoveries upon the mental progress

SIR HUMPHRY DAVY, P.R.S.

BY SIR T. LAWRENCE

of the civilised world which are being wrought by their practical applications to the cheapening of paper, and to improvements of the automatic printing-press, which, combined with the linking together of all parts of the earth by a network of telegraphic communications, put it in the power of even the poor of the realm to read daily the news of the world, and for a few shillings to provide themselves with a library of classical works. Of scarcely less educational influence upon the public mind are the new methods of photography and mechanical reproduction, by which pictures of current events and the portraits of those who are making contemporary history, and also copies of the world's masterpieces of painting and of sculpture, are widely disseminated with the cheap newspapers and magazines among the mass of the people.

I have not spoken of the influence of science upon its own students, nor of the place it should take in general education. My purpose has been to point out the profound changes which science has wrought upon the habits of thinking of the general public, who themselves have no personal knowledge of science methods, changes which have revolutionised every activity of the human mind.

Golden will be the days when, through a reform of our higher education, every man going up to the Universities will have been from his earliest years under the stimulating influence of a personal training in practical elementary science; all his natural powers being brought to a state of high efficiency, and his mind actively proving all things

under the vivifying influence of freedom of opinion. Throughout his days he will be on the best terms with Nature, living a longer and a fuller life under her protecting care, and, through the further disclosures of herself, rising successively to higher levels of being and of knowledge.

SCIENCE IN EDUCATION

AS a corollary to what I have said, the place that science should take in general education, very briefly considered, will suitably occupy the few minutes which remain. I do not wish to speak of science as a specialised subject of advanced study, nor of technical education, which is obviously of supreme importance to all who look forward to finding their life-work in manufacturing and industrial pursuits, or of entering such professions as architecture and civil and electrical engineering.

The importance to every man of a practical acquaint-

ance with elementary science is obvious. Would it be thought possible that any nation could act so absurdly as to teach its children other languages, and leave them in complete ignorance of the tongue of the land in which they would have to pass their lives? Would it not then be incredible, if it had not become a too familiar fact, that the public schools have, until recently, excluded all teaching of the science of Nature from their scheme of studies, though man's relation to Nature is more intimate than to his fellow-countrymen? We live, move, and have our being in Nature; we cannot emigrate from it, for we are part of it. Yet our higher education leaves men, who in other directions are well informed, much as deaf-mutes in the presence of Nature. They do not hear her most imperative warnings, and can only get on haltingly in their everyday intercourse with the natural forces to which their lives are subjected, by means of the arbitrary signs of empirical custom. The recent introduction of some amount of science teaching into our Higher Schools is quite inadequate, alike in kind and in degree. It can be only through a reform of the scheme of their examinations by the Universities, that we can hope to see science take the equal part with the humanities in general education, to which she is entitled.

The place of science in general education may be considered under two distinct aspects: the intrinsic value of the teaching of science as a means of enlarging the powers of the mind; and secondly, its relative

value and place as compared with the teaching of the classics.

The elements of the science of Nature, when properly taught, have a claim to a very high place in early general education, since Nature is always close about us as a living intelligence and power, which responds to the questions put to her by experiment. The young mind finds itself no longer in the realms of the dead, deciphering from the inscriptions on their tombstones, the history and opinions of past generations, invaluable as is such knowledge in its proper place, but in the open of light and life where Nature holds her school, taking all things, great and small, as the object lessons of her teaching.

Two faculties of the mind which it is of the highest importance, especially in early youth, to enlarge and develop by exercise, are wonder and imagination. Under the ordinary premature language teaching of the Grammar Schools, even the wonder and imagination natural to young minds become so stunted in their growth as to remain more or less dormant throughout life. On the other hand, natural science brings them into full activity, and greatly stimulates their development. Nature's fairy-tales, as read through the microscope, the telescope, and the spectroscope, or spelt out to us from the blue by waves of ether, are among the most powerful of the exciting causes of wonder in its noblest form, when free from terror it becomes the minister of delight and of mental stimulation.

And surely the master-creations of poetry, music, sculpture, and painting, alike in mystery and grandeur, cannot surpass the natural epics and scenes of the heavens above and of the earth beneath, in their power of firing the imagination, which indeed has taken its most daring and enduring flights under the earlier and simpler conditions of human life, when men lived in closer contact with Nature, and in greater quiet, free from the deadening rush of modern society. Of supreme value is the exercise of the imagination, that lofty faculty of creating and weaving imagery in the mind, and of giving subjective reality to its own creations, which is the source of the initial impulses to human progress and development, to all inspiration in the arts, and to discovery in science.

Further, elementary science, taught practically with the aid of experiment during a boy's early years, cannot fail to develop the faculty of observation. However keen in vision, the eyes see little without training in observation by the subtle exercise of the mind behind them. From the humblest weed to the stars in their courses, all Nature is a great object lesson for the acquirement of the power of rapid and accurate noting of minute and quickly changing aspects. Such an early training in the simpler methods of scientific observation confers upon a man for life the possession of an inexhaustible source of interest and delight, and no mean advantage in the keen competitions of the intellectual activities of the present day.

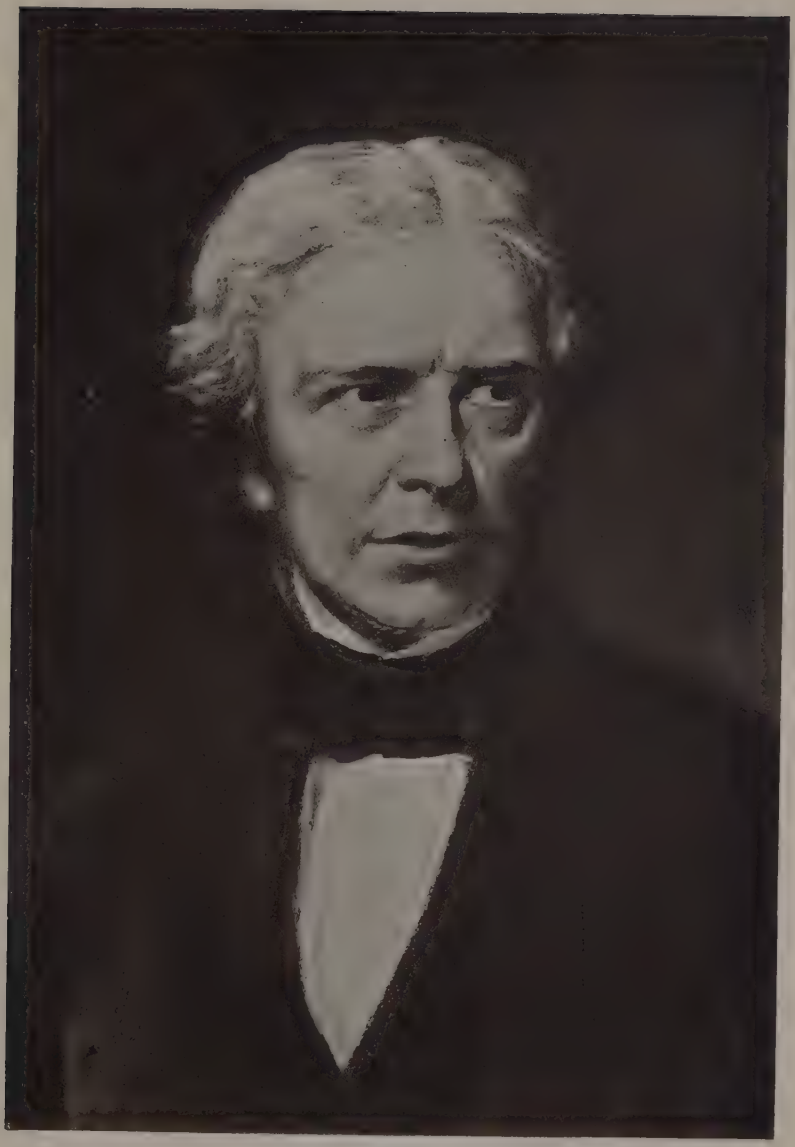
Training in the use of the eyes develops, at the same time, alertness of the intelligence and suppleness of the mind in dealing with new problems, which in after-life will be of great value in facing the unforeseen difficulties of all kinds which are constantly arising.

Science, practically taught, does more; for, under the constant control of his inferential conclusions by the unbending facts of direct experiment, the pupil gradually acquires the habit of reasoning correctly from the observations he makes. In particular, he learns the most precious lesson of great caution in forming his opinions, for he finds how often reasoning, which appeared to him to be flawless, was not really so, for it led him to wrong conclusions. Further, from the constant study of Nature the student comes so to look at things as almost unconsciously to discriminate between those which are essential and those which are only accidental, and so gradually to acquire the faculty of classing the facts of experience, and of putting them in their proper places in a consistent system or theory. Are there any other studies, it may be asked, by which, in the same time, a young mind could develop an equally enlarged capacity for correct reasoning, and acquire so wide an outlook? Yet, notwithstanding the immense intrinsic value of its teaching, science is but one of the studies which are necessary for a wide and liberal education. Intellectual culture, or, in other words, the whole mind working at its best, requires, besides the training of all its powers harmoniously by the study of

Nature, an acquaintance with many other kinds of knowledge, especially of human history and the development of human thought, and of the human arts. Humanistic studies and experimental science are equally essential, and indeed complement each other. Either alone leaves the mind unequally developed, and its whole attitude one-sided, and so produces a narrow type of mind which is incapable of taking a wide view even of its own side of thought, and has but little sympathy with any subject outside it.

In the scheme of a liberal education, literature and languages, which include the habit of clear thinking in suitable words, should have a large place. It must, I think, be conceded that the languages of ancient Greece and Rome, which are highly developed for the conveyance of delicate shades of thought, still stand unsurpassed as means of training in thinking in association with correct expression, while at the same time they feed the mind with the great ideas and the heroic deeds of the past.

In the methods of study of these languages, as actually carried out in the public schools, surely great reforms are possible. The complaint of the classicist, John Milton, who had been himself a schoolmaster, in his *Tractate on Education*, written about twenty years before the foundation of the Royal Society, is urgently true to-day. He wrote : " We do amiss to spend seven or eight years merely in scraping together so much miserable Latin and Greek as might be learned otherwise easily and delightfully in



MICHAEL FARADAY. F.R.S.

BY A. BLAIKLEY

one year." Later on, Evelyn made a similar complaint. "At most schools," he wrote, "there is a casting away of six or seven years in the learning of words only, and that, too, very imperfectly."

Quite recently the number of years usually given to Latin and Greek in the public schools has been shown by a striking experiment to be greatly excessive.

Last March the Minister of Education gave an account in the Prussian Chamber of the so-called "reform schools," in which the study of the classics is begun for Latin at twelve, and for Greek not until the age of fourteen, with the encouraging result that, of 125 pupils who presented themselves for the leaving examination, only four failed to pass, and, of these four, three succeeded three months later. Experience showed that, as the result of beginning Latin and Greek at a later age, the interest of the pupils in their work was much keener, and their progress much more rapid.

Improved methods of teaching the classical languages which would permit of the beginning of the study of them at a later age, would leave ample time for an early training in experimental science, so welcome to the young inquiring mind, which must soon come to be recognised as an essential part of all education.

In future no Grammar or Higher School should be considered as properly provided for, unless furnished with the necessary apparatus for teaching experimentally the fundamental principles of mechanics, physics, and biology. The

pupils should have the use of a small astronomical telescope, and of microscopes for biological work. Such apparatus and instruments can now be purchased at a very small cost.

Clearly, it is only by such a widening of the general education common to all who go up to the Universities, before specialisation is allowed, that the present "gap between scientific students careless of literary form, and classical students ignorant of scientific method," can be filled up, and the young men who will in the future take an active part in public affairs, as statesmen and leaders of thought, can be suitably prepared to introduce and encourage in the country that fuller knowledge and appreciation of science which are needed for the complete change of the national attitude on all science questions, which is absolutely necessary if we are to maintain our high position and fulfil our destiny as a great nation.

[I do not surely exaggerate the importance to the nation of the existence of the Royal Society, if I claim for it to have been, during the last two centuries, the faithful guardian of the true Palladium of the Empire, too long neglected and even forgotten by its peoples.

Sciencia vinces,—whether it be on the field of battle, on the waves of the ocean, amid the din and smoke of the workshop, or on the broad acres under the light of heaven ; and assuredly, in the future, even more than in the past, not only the prosperity, but even the existence of the Empire will be found to depend upon the "improvement of Natural

Knowledge,"—that is, upon the more complete application of scientific knowledge and methods to every department of industrial and national activity.

It is obvious that it must be so, for it is only through an increased understanding of what are called the laws of Nature—the sequence and the interaction of natural phenomena—that we can hope to bring Nature into complete subjection, and to make use of her illimitable forces to work out our own ends.]

As I address you now for the last time, I wish to say how fully I have appreciated the honour—the crowning honour—which can fall to the lot of but few Fellows, which I have received at your hands. Most deeply have I felt the great responsibility associated with this honour, and during a not uneventful period it has been my most earnest endeavour to uphold, as far as it lay in my power, the high traditions of our great and ancient Society.

In bidding you farewell, I desire to express to the entire body of the Fellows my gratitude for their invariable consideration and courtesy, and in particular to the Officers who have served with me, my warm thanks for their efficient support and assistance, and for the thoughtful and prevenient attention by which they have sought to lighten the duties of my office.

I rejoice that in the hands of my probable successor, a man of world-wide eminence in science, the interests and the reputation of the Society will be eminently safe.

Farewell! *Floreat Regalis Societas Londini!*

APPENDIX

COPY OF LETTER AND ENCLOSURE SENT TO THE UNIVERSITIES

THE ROYAL SOCIETY,
BURLINGTON HOUSE, LONDON, W.
January 21, 1904.

SIR,—The Address delivered by the President of the Royal Society (Sir William Huggins) at the anniversary meeting on December 1, 1902, was devoted in part to a consideration of the defects of the system of Secondary Education in this country, including the prevalent absence of initiation into scientific method and habits of observation. The public interest excited by this Address has led to urgent application to the Royal Society, from persons whose opinions carry great weight, that this subject should not be allowed to drop; and the Council have, moreover, been informed that some of those occupying the most responsible positions with regard to the Public Schools would welcome advice and assistance in this matter from outside. The President and Council of the Royal Society, after careful consideration, came to the conclusion that they would not be justified in entirely declining the task thus influentially pressed upon them; and they accordingly appointed a Special Committee to prepare the subject for detailed consideration, and especially to suggest a plan for inviting the active participation of the Universities in the problem of the im-

provement of education in Secondary Schools. At the same time, they adopted the following resolution :—

> "That the Universities be respectfully urged to consider the desirability of taking such steps in respect of their regulations as will, so far as possible, ensure that a knowledge of science is recognised in schools and elsewhere as an essential part of general education."

The recommendations of this Committee have received further prolonged consideration. As the result, we have been directed to submit the resolution quoted above to the Universities of the United Kingdom, and to express the strong conviction of the President and Council of the Royal Society that it is in the power of the Universities, by taking up this subject resolutely, and so far as possible in concert, to confer most substantial benefit on the nation. The Royal Society fully recognise that it is to the Universities, as bodies expert in educational affairs, that the initiation of a plan of procedure would naturally belong ; and they do not formally offer any detailed recommendations. We are, however, instructed to transmit for your information the statement enclosed, which is representative of a large body of scientific opinion, and may be of use in your deliberations.

We are, Sir, your obedient Servants,

J. LARMOR,
ARCH. GEIKIE, } *Secretaries, R.S.*

STATEMENT REGARDING SCIENTIFIC EDUCATION IN SCHOOLS, DRAWN UP BY A COMMITTEE OF THE ROYAL SOCIETY

Notwithstanding efforts extending over more than half a century, it still remains substantially true that the Public Schools have

devised for themselves no adequate way of assimilating into their system of education the principles and methods of science. The experience of "Modern sides" and other arrangements shows that it can hardly be expected that, without external stimulus and assistance, a type of public school education can be evolved which, whilst retaining literary culture, will at the same time broaden it by scientific interests. On the other hand, it is admitted that many students trained in the recent foundations for technical scientific instruction have remained ignorant of essential subjects of general education.

The bodies which can do most to promote and encourage improvement in these matters are the Universities, through the influence which they are in a position to exert on Secondary Education. This improvement will not, however, be brought about by making the avenues to degrees in scientific or other subjects easier than at present. Rather, the test of preliminary general education is too slight already, with the result that a wide gap is often established between scientific students careless of literary form and other students ignorant of scientific method.

It may be suggested that the Universities might expand and improve their general tests, so as to make them correspond with the education, both literary and scientific, which a student, matriculating at the age of nineteen years, should be expected to have acquired; and that they should themselves make provision, in cases where this test is not satisfied, for ensuring the completion of the general preliminary education of their students before close specialisation is allowed.

In particular, it appears desirable that some means should be found for giving a wider range of attainment to students preparing for the profession of teaching. The result of the existing system is usually to place the supreme control of a public school in the hands of a headmaster who has little knowledge of the scientific side of education; while the instructors in many colleges

have to deal with students who have had no training in the exact and orderly expression of their ideas.

Our main intention is not, however, to offer detailed suggestions, but to express our belief that this question of the adaptation of secondary education to modern conditions involves problems that should not be left to individual effort, or even to public legislative control; that it is rather a subject in which the Universities of the United Kingdom might be expected to lead the way and exert their powerful influence for the benefit of the nation.

October 1903.

PRESIDENTS OF THE ROYAL SOCIETY

The President is elected annually, and until recent years was eligible for re-election without any limit of time. About thirty years ago an unwritten law was established, by which the President, after having served five years, does not permit himself to be re-nominated for the office, thus restricting the maximum term of office to five years.

Name.	Date of election.	Years in office.
William, Lord Viscount Brouncker .	1663	14
Sir Joseph Williamson, Kt. . .	1677	3
Sir Christopher Wren, Kt. . .	1680	2
Sir John Hoskins, Bart. . . .	1682	1
Sir Cyril Wyche, Kt. . . .	1683	1
Samuel Pepys	1684	2
John, Earl of Carbery (Lord Vaughan)	1686	3
Thomas, Earl of Pembroke, K.G. .	1689	1
Sir Robert Southwell, Kt. . .	1690	5
Charles Montague (later Earl of Halifax)	1695	3

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Name.	Date of election.	Years in office.
John, Lord Somers	1698	5
Sir Isaac Newton, Kt.	1703	24
Sir Hans Sloane, Bart.	1727	14
Martin Folkes	1741	11
George, Earl of Macclesfield	1752	12
James, Earl of Morton (Lord Aberdour)	1764	4
James (afterwards Sir James) Burrow	1768	—
James West	1768	4
James Burrow	1772	—
Sir John Pringle, Bart.	1772	6
Sir Joseph Banks, Bart.	1778	41
William Hyde Wollaston	1820	—
Sir Humphry Davy, Bart.	1820	7
Davies Gilbert	1827	3
H.R.H. the Duke of Sussex	1830	8
The Marquis of Northampton	1838	10
The Earl of Rosse	1848	6
Lord Wrottesley	1854	4
Sir Benjamin Brodie, Bart.	1858	3
Sir Edward Sabine, K.C.B.	1861	10
Sir George Airy, K.C.M.G.	1871	2
Sir Joseph D. Hooker, G.C.S.I.	1873	5
William Spottiswoode	1872	5
Thomas Henry Huxley	1883	2
Sir George Stokes, Bart.	1885	5
Lord Kelvin, O.M.	1890	5
Lord Lister, O.M.	1895	5
Sir William Huggins, K.C.B., O.M.	1900	5
Lord Rayleigh, O.M.	1905	—

APPENDIX

MEDALS AWARDED BY THE ROYAL SOCIETY

The COPLEY MEDAL, founded in 1736 under the will (1709) of Sir Godfrey Copley, Bart., F.R.S., is awarded annually for distinguished philosophical research, and irrespective of nationality. It takes rank as the premier award of the Royal Society. It is struck in gold.

The RUMFORD MEDAL, founded by Count Rumford in 1796, is awarded biennially for the most important discoveries in heat or light during the preceding two years. The medal is struck in gold and in silver.

Two ROYAL MEDALS founded by George IV., and since continued by the grace of successive Sovereigns, are awarded annually for the two most important contributions to the advancement of Natural Knowledge published originally in the British dominions, within a period of not more than ten and not less than one year of the date of the award. They are struck in gold and in silver.

The DAVY MEDAL, founded in 1869 under the will of Dr. John Davy, F.R.S., brother of Sir Humphry Davy, is awarded annually for the most important discovery in chemistry made in Europe or Anglo-America. It is struck in gold.

The DARWIN MEDAL, founded in 1890, by subscription, is awarded biennially for work of distinction in the field in which Mr. Charles Darwin himself laboured. It is struck in silver or bronze.

The BUCHANAN MEDAL, founded in 1894, by subscription, is awarded every five years in respect of distinguished services to hygienic science or practice, in the direction either of original research or of professional, administrative, or constructive work, without limit of nationality or sex. It is struck in gold.

The SYLVESTER MEDAL, founded in 1897 as an international memorial of the late Prof. J. J. Sylvester, F.R.S., is awarded triennially for the encouragement of mathematical research, irrespective of nationality. It is struck in bronze.

APPENDIX

The HUGHES MEDAL, founded in 1900 under the will of D. E. Hughes, F.R.S., is awarded annually, without restriction of sex or nationality, for original discovery in the physical sciences, particularly electricity and magnetism or their applications. It is struck in gold.

THE LIBRARY

On the 2nd January 1666–1667, Mr. Henry Howard (afterwards sixth Duke of Norfolk) presented the Royal Society with "the Library of Arundel House, to dispose thereof as their property, desiring only that in case the Society should come to faile, it might return to Arundel House ; and that this inscription, *Ex dono Henrici Howard Norfolciensis*, might be put upon every book given them." "The Society," it is added, "received this noble donation with all thankfullnesse, and ordered that Mr. Howard should be registered as a benefactor." This gift may be regarded as the nucleus of the Society's Library.

A considerable part of the Arundel Library came originally from the collection of Matthias Corvinus, King of Hungary, a portion of which, after his death, passed into the possession of the celebrated Bilibald Pirckheimer, of Nuremberg, who died in 1530. This portion was purchased by Howard's grandfather, Thomas, Earl of Arundel, during his embassy at Vienna ; and it consisted of a great number of printed books and many rare and valuable manuscripts.* It may be mentioned that several of the books, which are still in the Society's possession, contain Bilibald Pirckheimer's book-plate, designed by Albrecht Dürer.

An entry in the Council Minutes of May 18, 1681, shows that the Arundel Library was at that time kept separate from the other books, and it probably remained so for many years. The volumes were afterwards, however, distributed according to subjects, and in

[1] Weld's *History*, Vol. I. p. 196.

process of time many were disposed of. Sales of books were made in 1713, 1745, and at subsequent dates. On June 20, 1872, the Council, on the recommendation of the Library Committee, resolved "to dispose of superfluous books from the collection of works on 'Miscellaneous Literature,'" and these probably included many "Arundel books." The most valuable of the printed books of purely literary interest retained by the Society were in 1883 collected together, under the superintendence of the Treasurer, Sir John Evans, in a case made for the purpose. They include a copy of Caxton's Chaucer, and two volumes, printed on vellum, by Fust and Schœffer, named the *Liber Sextus Decretalium cum glossis* (A.D. 1465), and Cicero's *Officia et Paradoxa* (A.D. 1466); a very perfect example of Albrecht Dürer's *Historia Mariæ, Passio Domini, et Apocalipsis*, in one volume (A.D. 1511); a copy of the *Nuremburg Chronicle*; a very fine copy of *Euclidis Elementa*, Editio Princeps (Venetiis. Ratdolt, 1482), with illuminated initials; a number of Editiones Principes of the Latin Classics, including many Aldines, a large collection of Luther's and of scarce Reformation tracts, and many other works of literary or typographical interest.

The bulk of the Arundel manuscripts was sold to the Trustees of the British Museum in 1830 for the sum of £3559, the proceeds being devoted to the purchase of scientific books; these manuscripts are still kept in the British Museum as a separate collection. A catalogue of all the manuscripts and printed books originally given to the Society by Henry Howard of Norfolk was printed in 1681, and a copy of the same is in the Society's Library.

The scientific books in the Library probably number about 60,000 volumes. In the purchase of books, special attention has for many years past been paid to scientific serials; and the collection of Journals and of the Transactions of Scientific Societies is now a very large one. The Council annually votes a sum of £400 for the purchase and binding of books.

A Catalogue of the Scientific Books in two octavo volumes is on sale. Part I. (1881) containing Transactions, Journals, etc., 5s.;

Part II. (1883), General Science, 15s. A reduction on these prices is made to Fellows. A List of Additions to the Library made during the year will be found in the *Year Book*.

The Regulations for the use of the Library are governed by Statutes, Chap. XIV., §§ 7–11 (see *Year Book*); and are embodied in rules which are printed in the *Year Book*. The books lent out are called in by order of Council usually once a year, at the beginning of the Long Vacation; and during the month of August no book is allowed to leave the house, though the Library is kept open for purposes of reference.

Besides the printed books, the Library contains a rich collection of scientific correspondence, official records, and other manuscripts, including the original manuscript, with Newton's autograph corrections, from which the first edition of the *Principia* was printed; the celebrated manuscript volume of the *Commercium Epistolicum*, relating to the Leibnitz-Newton controversy on the priority of the invention of fluxions; the manuscript of John Aubrey's *Memoires of Naturall Remarques in the County of Wilts*, written in 1685; a collection of over 300 letters by Leeuwenhoek; a collection of letters and manuscripts by Malpighi; a collection of letters by Henry Oldenburgh and Dr. J. Beale written to Robert Boyle; Henry Oldenburgh's Commonplace Book, containing drafts of his letters to Milton and to Robert Boyle; the autograph manuscript of Wallis's *Treatise on Logic*, published in the folio edition of his works; a large album containing original letters, portraits, and other memorials of Joseph Priestley, collected by James Yates, etc. Many of the manuscripts and most of the manuscript letters are given in the *Catalogue of Miscellaneous Manuscripts*, compiled by the late J. O. Halliwell-Phillipps, F.R.S., in 1840, which is on sale (price 2s.). Among the series not there catalogued are *The Boyle Papers*, bound in fifty-three volumes, the *Letter Books*, containing copies of the early scientific correspondence from the foundation of the Society to the end of the seventeenth century, the *Register Book* of the Royal Society, containing copies of scientific memoirs communicated to the Society from 1661 to

1738, in twenty-one volumes ; the *Journal Book*, containing minutes of the Society's meetings from 1660 to the present time ; the *Council Minutes*, from the foundation of the Society ; and a series of guard-books, containing the original manuscripts of early memoirs communicated to the Society, arranged under subjects. The manuscripts of the *Philosophical Transactions* and *Proceedings*, and the papers read before the Society but not published, are bound into volumes and preserved for reference, as also are the *Certificates of Candidature*, in which the qualifications of candidates are stated, and to which the signatures of supporters are attached.

All the above-mentioned manuscripts, and others not here specified, are open to the inspection of Fellows, but the loan of them is exclusively vested in the Council. (*From the Record of the Royal Society.*)

INSTRUMENTS AND HISTORICAL RELICS IN THE POSSESSION OF THE ROYAL SOCIETY

Relics of Sir Isaac Newton

1. Solar Dial cut in stone, made by the hand of Sir Isaac Newton when a boy, taken out in 1844 from the wall of the Manor House at Woolsthorpe in which he was born, and presented the same year to the Royal Society by the Rev. Chas. Turnor, F.R.S., to whose family the house belonged.

2. Two rules made of the wood of Sir Isaac Newton's apple tree at Woolsthorpe. *Presented by Rev. Chas. Turnor, F.R.S.*

3. Original Reflecting Telescope of Sir Isaac Newton, made with his own hands in 1671. (*Phil. Trans.*, vol. vii. p. 4004.) *Presented to the Royal Society by Messrs. Heath & Wing, Math. Inst. Makers, Strand, London ; Feb.* 6, 1766. 4 parts.

4. The manuscript of the *Principia*, from which the First Edition was printed, with autograph corrections by Sir Isaac Newton.

5. An autograph order, dated July 27, 1720, addressed by Sir Isaac Newton to Dr. John Francis Ffouquier, directing him to apply certain sums belonging to Newton in purchasing, on Newton's account, South Sea Stock. *Presented by Dr. Wollaston, P.R.S.*

6. The original Mask of Newton's face, which belonged to Roubillac, from the cast taken after death. *Presented in* 1839 *by Prof. Hunter Christie, Sec. R.S.*

7. Sir Isaac Newton's Watch.

8. A lock of Sir I. Newton's Hair. *Presented by Henry Garling, Oct.* 25, 1847.

9. Armchair, formerly belonging to Sir Isaac Newton. Bequeathed in 1812 to Richard Saumarez. *Bequeathed to the Royal Society in* 1891 *by the late Mr. Thomas Kerslake of Clevedon.*

Other Relics and Instruments

1. Air-pump, with double barrel. *Presented to the Royal Society by the Hon. Robert Boyle in* 1662.

2. Sir William Petty's Double-bottomed boat.

> "Upon the reading of a letter, sent out of Ireland to the Secretary, concerning the expectation, which the Committee, that heretofore had given the Society an Account of S^r^ William Petty's new ship, did entertain for hearing the sense of the Society thereupon, it was
>
> "Ordered, That the Committee should be put in minde by the Secretary that the Matter of Navigation, being a State-concerne, was not proper to be managed by the Society; And that S^r^ William Petty, for his private satisfaction, may, when he pleases, have the sense (if he hath it not already) of particular Members of the Society, concerning his new Invention."—*Council Minutes*, May 27, 1663.
>
> "The Papers of the next Philosophical Transactions, having been considered of, and the account therein given concerning the Structure and Advantages of S^r^ William

Petty's Double-bottom'd ship; it was resolved, that the publication of them should be differed, till his Ma^ty had been made acquainted with the particulars therein, relating to the said ship."—*Council Minutes*, April 26, 1665.

3. Huygens's Aerial Telescope.

(1) An Object-glass of 22 feet focal length, with an eye-glass of 6 inches, and original apparatus for adjustment, made by Huygens, and presented by him to the Royal Society in 1691.

(2) The apparatus for using Huygens's object-glass, constructed by Hooke.

(3) Additional apparatus, by Dr. Pound. *Presented by Dr. Bradley.*

(4) Ditto, by Mr. Cavendish.

} 12 parts.

4. An Object-glass by Huygens, of 170 feet focal length. *Presented to the Royal Society by Sir Isaac Newton, P.R.S.*

5. An Object-glass by Huygens, with two eye-glasses by Scarlet, for a Telescope of 210 feet. *Presented by the Rev. Gilbert Burnet, M.A., F.R.S., in* 1724.

6. An Object-glass (Venetian), of 90 feet focal length, which belonged to Flamsteed. *Presented to the Royal Society by James Hodgson, F.R.S., in* 1737.

7. Convertible Pendulum of Captain Kater; with the Agate Planes.

The basis of the present system of British Weights and Measures.—Phil. Trans., 1818, p. 37.

8. Chronometer, by Arnold.

9. Chronometer, by Arnold.

Both these Chronometers accompanied Captain Cook on his second and third Voyages.

10. Armed Loadstone.

Grew's *Catalogue of Rarities* (p. 364) mentions an *Orbicular Loadstone or Ter[r]ella*, given by Sir Christopher Wren, the size of which, so far as the stone is concerned,

agrees with the above; it is conjectured that it may be the same.

11. A Galvanic Battery, made by Dr. Wollaston, in a tailor's thimble. *Presented to the Royal Society by Sir A. W. Franks, June* 28, 1879.

In a letter to the late William Spottiswoode, P.R.S., which accompanied this present, Sir (then Mr.) Augustus Wollaston Franks says that this little battery was given by his godfather, Dr. Wollaston, to his mother, then Miss Sebright. See also an anecdote about this battery in Weld's *History of the Royal Society*, vol. ii. p. 309.

12. Dr. Priestley's Electrical Machine.

13. The original Model for Davy's Safety Lamp.

14. The Mountain Barometer used by the late Mr. Charles Darwin, F.R.S., during his voyage round the world in H.M.S. Beagle. *Presented by his executors in December* 1899.

The remainder of the instruments lately in the possession of the Society have been deposited in the Victoria and Albert Museum, South Kensington.

(*From the Record of the Royal Society.*)

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